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Real Power Loss Reduction by Moth Search and Intermingled Algorithm’s

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Abstract

In this article Moth Search Algorithm (MSA) and Intermingled algorithm (IA) is proposed to solve optimal reactive power problem. Moths are associated in to the order Lepidoptera. Amongst the characteristics of moths, the phototaxis and Levy flights are main features. Phototaxis and Levy flights of moths are used for formulating the algorithm. Moth will impulsively be inclined to do in most excellent mode to regulate the flight orientation such that it moves towards the light source but be the for source for flying moths that tumbling downward. In this article Intermittent search strategy, Eagle strategy, and Flower pollination algorithm has been combined (called as intermingled algorithm) to solve the optimal reactive power problem. At first in the exploration stage Intermittent search strategy is utilized then Eagle strategy is combined; first stage it does the exploration and latter it will do exploitation. Finally, Flower pollination algorithm is utilized to upgrade the process of the algorithm. Proposed Moth Search Algorithm (MSA) and Intermingled algorithm (IA) has been tested in standard IEEE 14, 30 bus test systems and simulation results show the projected algorithms reduced the real power loss efficiently.

Keywords: ***Optimal reactive power, Transmission loss, Moth search, Intermingled algorithm.***

1. Introduction

Reactive power problem plays an important role in secure and economic operations of power system. Numerous types of methods [1-6] have been utilized to solve the optimal reactive power problem. However, many scientific difficulties are found while solving problem due to an assortment of constraints. Evolutionary techniques [7-17] are applied to solve the reactive power problem. This paper proposes Moth Search Algorithm (MSA) and Intermingled algorithm (IA) to solve optimal reactive power problem. Angle between moth and the light source continue to be altering, however it frequently gets away from observation, because extraterrestrial objects are so far away. When a moth is close to the light source it uses for navigation, but the change in angle will be evidently noticeable, even from a little distance. Obviously, it forms a spiral flight path that gets nearer and nearer to the light source. In the structure of Levy flights

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moths are always flying around their own positions with smaller distance from the best one. At a defined distance from best moth, other moths are situated around and considering best moth to be the target. Then ***i***n this work Intermittent search strategy, Eagle strategy, Flower pollination algorithm has been combined (called as intermingled algorithm) to solve the optimal reactive power problem. The exploration & exploitation has been improved substantially. At first in the exploration stage Intermittent search strategy is utilized then Eagle strategy is combined; first stage it does the exploration & latter it will do exploitation, finally Flower pollination algorithm utilized to upgrade the process of the algorithm. Proposed Moth Search Algorithm (MSA) and Intermingled algorithm (IA) has been tested in standard IEEE 14, 30, bus test systems and simulation results show the projected algorithms reduced the real power loss effectively.

2. Problem Formulation

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

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

Voltage deviation given as follows:

$$F = P_L + \omega_v \times \text{Voltage Deviation} \qquad (2)$$

Voltage deviation given by:

$$\text{Voltage Deviation} = \sum_{i=1}^{Npq} |V_i - 1| \qquad (3)$$

Constraint (Equality)

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

Constraints (Inequality)

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

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

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

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

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

3. Moth Search Algorithm

Moths are associated in to the order Lepidoptera. Amongst the characteristics of moths, the phototaxis and Levy flights are main features [14]. When a moth is close to the light source it uses for navigation, but the change in angle will be evidently noticeable, even from a little distance. Obviously, it forms a spiral flight path that gets nearer and nearer to the light source. In the structure of Levy flights moths are always flying around their own positions with smaller distance from the best one. At a defined distance from best moth, other moths are situated around and considering best moth to be the target. Levy flight is a rank of non-Gaussian random processes whose arbitrary walks are drawn from Levy stable distribution. This allocation is a simple power-law formula $L(s) \sim |s|^{-1-\beta}$where $0 < \beta < 2$ is an index.

$$L(s,\gamma,\mu) = \begin{cases} \sqrt{\frac{\gamma}{2\pi}} \quad exp\left[-\frac{\gamma}{2(s-\mu)}\right]\frac{1}{(s-\mu)^{3/2}} & if\ 0 \ < \mu < s < \infty \\ 0 \quad if\ s \leq 0 \end{cases} \tag{10}$$

$$F(k) = exp\left[-\alpha|k|^{\beta}\right], 0 < \beta \leq 2, \tag{11}$$

$$Y^{t+1} = Y^{t} + \alpha \oplus Levy\ (\beta) \tag{12}$$

$$Y^{t+1} = Y^{t} + random\ \big(size(D)\big) \oplus Levy(\beta) \tag{13}$$

A non-trivial scheme of generating step size s samples are summarized as follows,

$$Y^{t+1} = Y^{t} + random\ \big(size(D)\big) \oplus Levy(\beta) \sim 0.01\frac{u}{|v|^{1/\beta}}\left(y_j^t - gb\right) \tag{14}$$

Where *u* and *v* are drawn from normal distributions, that is

$$u \sim N(0, \sigma_u^2) \quad v \sim N(0, \sigma_v^2) \tag{15}$$

$$\sigma_u = \left\{\frac{\Gamma(1+\beta) sin(\pi\beta/2)}{\Gamma[(1+\beta)/2]\beta 2^{(\beta-1)/2}}\right\}^{1/\beta}, \sigma_v = 1 \tag{16}$$

Moths positions are modernized by performing Levy flights,

$$y_i^{t+1} = y_i^t + \alpha L(s) \tag{17}$$

In this work “α" is scale factor and found by,

$$\alpha = S_{max}/t^2 \tag{18}$$

Towards that source of light certain moths are will fly in line. This procedure can be defined as follows. For moth *i* , its flights can be formulated as,

$$y_i^{t+1} = \lambda \times \left(y_i^t + \varphi \times (y_{best}^t - y_i^t)\right) \tag{19}$$

Towards the ending position that is beyond the light source some moths may fly, for this case, the ending position for moth *i* can be formulated as follows:

$$y_i^{t+1} = \lambda \times \left(y_i^t + \frac{1}{\varphi} \times (y_{best}^t - y_i^t) \right) \tag{20}$$

```
Start
Step a: Initialization of parameters
Step b: Evaluation of the fitness; each moth individual fitness value will be calculated with respect to its position.
Step c: While t<MaxGen do; classify all the moth individuals by their fitness value.
    For i= 1 to NP/2 (for all moth individuals in Subpopulation 1) do
        By performing Levy flights Engender $x_i^{t+1}$
    End for i
    For i= NP/2+1 to NP (for all moth individuals in Subpopulation 2) do
        If random > 0.5 then
            Engender $y_i^{t+1}$ through $y_i^{t+1} = \lambda \times (y_i^t + \varphi \times (y_{best}^t - y_i^t))$
        Else
            Engender $y_i^{t+1}$ through $y_i^{t+1} = \lambda \times \left( y_i^t + \frac{1}{\varphi} \times (y_{best}^t - y_i^t) \right)$
        End if
    End for i
    Calculate the population as per the recently modernized positions
    t = t+1.
Step d: end while
Step e: Output the most excellent solution.
End
```

4. Intermingled Algorithm

In this projected algorithm at first Intermittent search strategy [15,16] is utilized & it has been utilized in the exploration stage. τ_a and τ_R be the mean times used up in intensive detection stage and given as

$$D\nabla_r^2 t_1 + \frac{1}{2\pi\tau_a} \int_0^{2\pi} [t_2(r) - t_1(r)]\, d\theta + 1 = 0, \tag{21}$$

$$u \cdot \nabla_r t_2(r) - \frac{1}{\tau R} [r_2(r) - t_1(r)] + 1 = 0, \tag{22}$$

Balancing of two stages in the process can be done by,

$$r_{optimal} = \frac{\tau_a}{\tau_R^2} \approx \frac{D}{a^2} \frac{1}{\left[2 - \frac{1}{in(R/a)}\right]^2} \tag{23}$$

Then Eagle strategy [17] is combined and first stage it does the exploration & latter it will do exploitation. In this approach, mainly p_e directly the exchange between local and global search. After that Flower pollination algorithm [18] combined in the process of the projected algorithm.

In this approach flower reliability can be characterized scientifically as

$$y_i^{t+1} = y_i^t + \gamma L(\lambda)(y_i^t - g_*) \qquad (24)$$

Then draw $L > 0$ from a Levy distribution

$$L \sim \frac{\lambda \Gamma(\lambda sin(\Pi\lambda/2))}{\Pi} \frac{1}{s^{1+\lambda}} \text{ , } (s \gg s_0 > 0) \qquad (25)$$

Local pollination drafted as follows,

$$y_i^{t+1} = y_i^t + \in \left(y_j^t - y_k^t\right) \qquad (26)$$

As Eagle Strategy is a two-stage strategy, for the large extent search stage is done through randomization via Levy flights. Balance of local search and global search is very significant, & it done through Eagle Strategy. The optimal ratio of exploitation and exploration is given by,

$$\tau_a/\tau_R^2 \approx 1/8 \qquad (27)$$

```
Initialization through arbitrary preliminary assumption
While (stop criterion); Global exploration done in arbitrary mode
Calculate the objective function; If $p_e$<random, exchange to a local search
Exhaustive local search will be done in the region of a competent solution
If (a enhanced solution is found); Update the existing best
End
Modernize t = t + 1
Locate the most excellent solution $g_*$in the preliminary population
Describe a control probability p ∈[0, 1] ;Stopping criterion (fixed number of    generations/iterations)
While (t <Maximum Generation)
For i= 1 : n (all n flowers in the population)
If random <p,
Global pollination through $y_i^{t+1} = y_i^t + L(y_i^t - g_*)$
Else
Local pollination through $y_i^{t+1} = y_i^t + \in \left(y_j^t - y_k^t\right)$
End if
Calculate new-fangled solutions
If new-fangled solutions are better, update them in the population
End for
Find the current best solution $g_*$
```

End while

Output - most excellent solution has been found

5. Simulation Results

At first in standard IEEE 14 bus system [19] the validity of the proposed Moth Search Algorithm (MSA) and Intermingled algorithm (IA) has been tested, Table 1 shows the constraints of control variables. Table 2 shows the limits of reactive power generators and comparison results are presented in Table 3.

Table 1: Constraints of Control Variables.

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 14 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Table 2: Constrains of Reactive Power Generators

System	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 14 Bus	1	0	10
	2	-40	50
	3	0	40
	6	-6	24
	8	-6	24

Table 3: Simulation Results of IEEE −14 System.

Control variables	Base case	MPSO [20]	PSO [20]	EP [20]	SARGA [20]	MSA	IA
$VG-1$	1.060	1.100	1.100	NR*	NR*	1.014	1.015
$VG-2$	1.045	1.085	1.086	1.029	1.060	1.029	1.033
$VG-3$	1.010	1.055	1.056	1.016	1.036	1.028	1.029
$VG-6$	1.070	1.069	1.067	1.097	1.099	1.019	1.021
$VG-8$	1.090	1.074	1.060	1.053	1.078	1.026	1.029
Tap 8	0.978	1.018	1.019	1.04	0.95	0.912	0.914
Tap 9	0.969	0.975	0.988	0.94	0.95	0.921	0.923
Tap 10	0.932	1.024	1.008	1.03	0.96	0.903	0.914
$QC-9$	0.19	14.64	0.185	0.18	0.06	0.132	0.133
PG	272.39	271.32	271.32	NR*	NR*	271.86	271.92
QG (Mvar)	82.44	75.79	76.79	NR*	NR*	75.73	75.78
Reduction in PLoss (%)	0	9.2	9.1	1.5	2.5	22.69	22.56
Total PLoss (Mw)	13.550	12.293	12.315	13.346	13.216	10.475	10.492
NR* - Not reported.							

Then the proposed Moth Search Algorithm (MSA) and intermingled algorithm (IA) has been tested, in IEEE 30 Bus system. Table 4 shows the constraints of control variables, Table 5 shows the limits of reactive power generators and comparison results are presented in Table 6.

Table 4: Constraints of Control Variables.

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 30 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Table 5: Constrains of Reactive Power Generators.

System	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 30 Bus	1	0	10
	2	-40	50
	5	-40	40
	8	-10	40
	11	-6	24
	13	-6	24

Table 6: Simulation Results of IEEE −30 System.

Control variables	Base case	MPSO [20]	PSO [20]	EP [20]	SARGA [20]	MSA	IA
$VG-1$	1.060	1.101	1.100	NR*	NR*	1.029	1.033
$VG-2$	1.045	1.086	1.072	1.097	1.094	1.023	1.031
$VG-5$	1.010	1.047	1.038	1.049	1.053	1.017	1.019
$VG-8$	1.010	1.057	1.048	1.033	1.059	1.021	1.030
$VG-12$	1.082	1.048	1.058	1.092	1.099	1.018	1.019
VG-13	1.071	1.068	1.080	1.091	1.099	1.024	1.020
Tap11	0.978	0.983	0.987	1.01	0.99	0.927	0.921
Tap12	0.969	1.023	1.015	1.03	1.03	0.929	0.933
Tap15	0.932	1.020	1.020	1.07	0.98	0.926	0.927
Tap36	0.968	0.988	1.012	0.99	0.96	0.928	0.929
QC10	0.19	0.077	0.077	0.19	0.19	0.094	0.090
QC24	0.043	0.119	0.128	0.04	0.04	0.105	0.103
PG (MW)	300.9	299.54	299.54	NR*	NR*	297.82	297.89
QG (Mvar)	133.9	130.83	130.94	NR*	NR*	131.49	131.51
Reduction in PLoss (%)	0	8.4	7.4	6.6	8.3	17.16	15.72
Total PLoss (Mw)	17.55	16.07	16.25	16.38	16.09	14.537	14.791

6. Conclusion

In this article Moth Search Algorithm (MSA) and intermingled algorithm (IA) successfully solved the optimal reactive power problem. IN MSA approach, when a moth is close to the light source it uses for navigation, but the change in angle will be evidently noticeable, even from a little distance. At a defined distance from best moth, other moths are situated around and considering best moth to be the target. In this article combination of Intermittent search strategy, Eagle strategy, Flower pollination algorithm has successfully solved the optimal reactive power problem. Exploration and exploitation have been improved by the combination of the three techniques. Proposed Moth Search Algorithm (MSA) and intermingled algorithm (IA) has been tested in standard IEEE 14, 30 bus test systems and simulation results show the projected algorithms reduced the real power loss effectively.

REFERENCES

1. Lee KY. Fuel-cost minimisation for both real and reactive-power dispatches. Proc Generation, Transmission and Distribution Conf. 1984;131(3):85-93.
2. Deeb NI. An efficient technique for reactive power dispatch using a revised linear programming approach," Electr Pow Syst Res. 1998;15(2):121–134.
3. Bjelogrlic MR, Calovic M.S, Babic BS. Application of Newton's optimal power flow in voltage/reactive power control. IEEE Trans Power Syst. 2990; 5(4):1447-1454.
4. Granville S. Optimal reactive dispatch through interior point methods. IEEE Trans Power Syst. 1994;9(1):136–146.
5. Grudinin N. Reactive power optimization using successive quadratic programming method. IEEE Trans Power Syst. 1998;13(4):1219–1225.
6. Ng Shin Mei R, Sulaiman MH, Mustaffa Z, et al. Optimal reactive power dispatch solution by loss minimization using moth-flame optimization technique. Appl Soft Comput. 2017;59:210–222.
7. Chen G, Liu L, Zhang Z, et al. Optimal reactive power dispatch by improved GSA-based algorithm with the novel strategies to handle constraints. Appl Soft Comput. 2017;50:58–70.
8. Naderi E, Narimani H, Fathi M, et al. A novel fuzzy adaptive configuration of particle swarm optimization to solve large-scale optimal reactive power dispatch. Appl Soft Comput. 2017:53:441–456.
9. Heidari AA, Abbaspour A, Rezaee Jordehi R. Gaussian bare-bones water cycle algorithm for optimal reactive power dispatch in electrical power systems. Appl Soft Comput. 2017;57:657–671.
10. Morgan M, Rul Hasma Abdullah N, Herwan Sulaiman M, et al. 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). J Electr Syst. 2016;12(1):121-132.
11. Ng Shin Mei R, Herwan Sulaiman M, Mustaffa Z. Ant lion optimizer for optimal reactive power dispatch solution. J Elect Sys. 2015:68-74.
12. Anbarasan P, Jayabarathi T. Optimal reactive power dispatch problem solved by symbiotic organism search algorithm. In Proc Innov Power Advan Comput Technol, 2017, doi: 10.1109/IPACT.2017.8244970.
13. Basu M. Quasi-oppositional differential evolution for optimal reactive power dispatch. Int J Electr Power Energy Syst. 2016;78:29-40.
14. Wang GG. Moth search algorithm: A bio-inspired metaheuristic algorithm for global optimization problems. Memetic Comp. 2016;10:151–164.
15. B´enichou O, Loverdo C, Moreau M, et al. Two-dimensional intermittent search processes: An alternative to L´evy flight strategies. Phys Rev E Stat Nonlin Soft Matter Phys. 2016; 74(2 Pt 1):020102.
16. B´enichou O, Loverdo C, Moreau M, et al. Intermittent search strategies. Rev Mod Phys. 2011;83:81-129.
17. Yang, XS, and Deb S. Eagle strategy using L´evy walk and firefly algorithm for stochastic optimization. In: Nature Inspired Cooperative Strategies for Optimization (NICSO 2010) (eds. Gonzalez JR et al.) 2010;284:101-111.
18. Yang XS. Flower pollination algorithm for global optimization. In: Unconventional Computation and Natural Computation, Lecture Notes in Computer Science. 2012;7445:240-249.
19. IEEE, "The IEEE-test systems, 1993, [Online]. Available: http://www.ee.washington.edu/trsearch/pstca/

20. Nasser Hussain A, Abdulabbas Abdullah A, and Muhammed Neda O. Modified particle swarm optimization for solution of reactive power dispatch. Res J Appl Sci Eng Technol. 2018;15(8):316-327.

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