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Power loss reduction by gryllidae optimization algorithm

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ABSTRACT

This paper projects Gryllidae Optimization Algorithm (GOA) has been applied to solve optimal reactive power problem. Proposed GOA approach is based on the chirping characteristics of Gryllidae. In common, male Gryllidae chirp, on the other hand some female Gryllidae also do as well. Male Gryllidae draw the females by this sound which they produce. Moreover, they caution the other Gryllidae against dangers with this sound. The hearing organs of the Gryllidae are housed in an expansion of their forelegs. Through this, they bias to the produced fluttering sounds. Proposed Gryllidae Optimization Algorithm (GOA) has been tested in standard IEEE 14, 30 bus test systems and simulation results show that the projected algorithms reduced the real power loss considerably.

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1. INTRODUCTION

Reactive power problem plays a key role in secure and economic operations of power system. Optimal reactive power problem has been solved by variety of types of methods [1-6]. Nevertheless numerous 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, but the main problem is many algorithms get stuck in local optimal solution & failed to balance the Exploration & Exploitation during the search of global solution. This paper projects Gryllidae Optimization Algorithm (GOA) has been applied to solve optimal reactive power problem. Proposed algorithm based on the chirping characteristics of Gryllidae and formulated to solve the optimal reactive power problem. In common, male Gryllidae chirp, on the other hand some female Gryllidae also do as well. Male Gryllidae draw the females by this sound which they produce. Male Gryllidae create this sound by chirping the wings and known as stridulating. They attract each other by this sound for mating and keep the others from their nests. Moreover, they caution the other Gryllidae against dangers with this sound. The hearing organs of the Gryllidae are housed in an expansion of their forelegs. Through this, they bias to the produced fluttering sounds. Proposed Gryllidae Optimization Algorithm (GOA) has been tested in standard IEEE 14, 30 bus test systems and simulation results show that the projected algorithms reduced the real power loss considerably.

2. PROBLEM FORMULATION

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

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

voltage deviation given as follows:

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

voltage deviation given by:

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

constraint (equality)

$$P_G = P_D + P_L \tag{4}$$

constraints (Inequality)

$$P_{gslack}^{min} \le P_{gslack} \le P_{gslack}^{max} \tag{5}$$

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g \tag{6}$$

$$V_i^{min} \le V_i \le V_i^{max}, i \in N \tag{7}$$

$$T_i^{min} \le T_i \le T_i^{max}, i \in N_T \tag{8}$$

$$Q_c^{min} \le Q_c \le Q_C^{max}, i \in N_C \tag{9}$$

3. GRYLLIDAE OPTIMIZATION ALGORITHM

Gryllidae optimization algorithm based on the chirping characteristics of Gryllidae and formulated to solve the optimal reactive power problem. In common, male Gryllidae chirp, on the other hand some female Gryllidae also do as well. Male Gryllidae draw the females by this sound which they produce. Male Gryllidae create this sound by chirping the wings and known as stridulating. They attract each other by this sound for mating and keep the others from their nests. Moreover, they caution the other Gryllidae against dangers with this sound. The hearing organs of the Gryllidae are housed in an expansion of their forelegs. Through this, they bias to the produced fluttering sounds. Temperature (T_f) in degrees Fahrenheit is calculated from the chirp (N_c (per minute)) by,

$$T_f = 50.00 + \frac{Number\ of\ chrips\ (N_c) - 40.00}{4.00} \tag{10}$$

temperature in degrees Celsius (T_c), is defined by,

$$T_c = 10.00 + \frac{Number\ of\ chrips\ (N_c) - 40.00}{7.00} \tag{11}$$

chirping rate can be calculated based on T_c and T_f is found by,

$$N_c = (T_c - 10.00) * 7.00 + 40.00 \tag{12}$$

$$N_c = \left(T_f - 50.00\right) * 4.00 + 40.00 \tag{13}$$

velocity of sound is calculated by via the temperature attained with reference to the Dolbear law

$$V = 20.1^* \sqrt{273 + C} \tag{14}$$

frequency of the sound is given by,

$$f = \frac{V}{\lambda} \tag{15}$$

intensity of the sound inversely proportional to the square of the distance,

$$I = \frac{W}{4\pi r^2} = \frac{p}{\rho c}\ ; W = I * 4\pi r^2 \tag{16}$$

sound propagation level found by,

$$L_p = L_w + 10^{*} log[Q/4\pi r^2] \tag{17}$$

atmosphere sound absorption is given by,

$$A_{atmos} = 7.4(f^2 r/\Phi)10^{-8} \tag{18}$$

free filed sound pressure is given by,

$$L_p' = L_p - A_{atmos} \tag{19}$$

frequency, velocity, position value obtained by,

$$f_i = f_{minimum} + (f_{maximum} - f_{mimimum})\beta \tag{20}$$

$$v_i^t = v_i^{t-1} + (x_i - x_*) f_i + V_i \tag{21}$$

$$x_i^t = x_i^{t-1} + v_i^t \tag{22}$$

random walk [18] is done through,

$$x_i = x_{best} + 0.01 * random(0,1) \tag{23}$$

in the period of the modernizing procedure, Euclidian distances (r) among all of the Gryllidae in the population were computed by,

$$K = Koe^{-\gamma r^2} \tag{24}$$

$$x_i = x_i + Koe^{-\gamma r_{ij}^2} + \alpha \in_i \tag{25}$$

Commence
For i=1 to n do
$x_i \leftarrow engender\ initial\ solution$ ( )
End
$i_{min} \leftarrow argmin_i\, s(x_i)$
$F_{min} \leftarrow argmin\, s(x_i)$
$x_i min \leftarrow argmin_{xi}\, s(x_i)$
For i=1 to t do
$while(F_{minimum} > Tol)$
For i=1 to n do
$N_i \leftarrow engender\ random\ vector$
$T_i \leftarrow Dolbear\ law\ (N_i)$
$c_i = (5/9)T_i - 32$
$V_i \leftarrow V = 20.1^{*}\sqrt{273 + C}, \lambda \leftarrow x_i - x_{best}$
$F_{maximum} \leftarrow f = \frac{V}{\lambda}, f_i, v_i^t, x_i^t \leftarrow f_i = f_{minimum} + (f_{maximum} - f_{mimimum})\beta$, $v_i^t = v_i^{t-1} + (x_i - x_*) f_i + V_i, x_i^t = x_i^{t-1} + v_i^t$
$\gamma \leftarrow compute\ the$ Coefficient
$if\ random[0,1] > \gamma$
For j =1 to n do
$if\ s_i < s_j\ then\ r_j \leftarrow K = Koe^{-\gamma r^2}$
$Ps \leftarrow I = \frac{W}{4\pi r^2} = \frac{p}{\rho c}\ ; W = I * 4\pi r^2$
$LP \leftarrow L_p = L_w + 10^{*} log[Q/4\pi r^2]$
$A_{atmos} \leftarrow A_{atmos} = 7.4(f^2 r/\Phi)10^{-8}$

$RL_p \leftarrow L'_p = L_p - A_{atmos}$
$K_0 \leftarrow RL_p, K_i \leftarrow x_i = x_i + Koe^{-\gamma r_{ij}^2} + \alpha \in_i$
$x_i \leftarrow x_i = x_{best} + 0.01 * random(0,1)$
End
$F_{new} \leftarrow cost\ function(x_i)$
$if\ (F_{new} < F_{minimum})$
$x_{best} = x_i$
$F_{minimum} = F_{new}$
End
Find the most excellent solution
End

4. SIMULATION RESULTS

At first in standard IEEE 14 bus system the validity of the proposed Gryllidae Optimization Algorithm (GOA) 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.

Then the proposed Gryllidae Optimization Algorithm (GOA) simulated 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 1. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 14 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	o.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 [19]	PSO [19]	EP [19]	SARGA [19]	GOA
VG−1	1.060	1.100	1.100	NR*	NR*	1.004
VG−2	1.045	1.085	1.086	1.029	1.060	1.014
VG−3	1.010	1.055	1.056	1.016	1.036	1.009
VG−6	1.070	1.069	1.067	1.097	1.099	1.002
VG−8	1.090	1.074	1.060	1.053	1.078	1.011
Tap 8	0.978	1.018	1.019	1.04	0.95	0.900
Tap 9	0.969	0.975	0.988	0.94	0.95	0.911
Tap 10	0.932	1.024	1.008	1.03	0.96	0.901
QC−9	0.19	14.64	0.185	0.18	0.06	0.124
PG	272.39	271.32	271.32	NR*	NR*	271.46
QG (Mvar)	82.44	75.79	76.79	NR*	NR*	75.04
Reduction in PLoss (%)	0	9.2	9.1	1.5	2.5	12.33
Total PLoss (Mw)	13.550	12.293	12.315	13.346	13.216	11.879

NR - Not reported.*

Table 4. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 30 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	o.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 [19]	PSO [19]	EP [19]	SARGA [19]	GOA
$VG{-}1$	1.060	1.101	1.100	NR*	NR*	1.010
$VG{-}2$	1.045	1.086	1.072	1.097	1.094	1.008
$VG{-}5$	1.010	1.047	1.038	1.049	1.053	1.012
$VG{-}8$	1.010	1.057	1.048	1.033	1.059	1.049
$VG{-}12$	1.082	1.048	1.058	1.092	1.099	1.032
VG-13	1.071	1.068	1.080	1.091	1.099	1.023
Tap11	0.978	0.983	0.987	1.01	0.99	0.912
Tap12	0.969	1.023	1.015	1.03	1.03	0.905
Tap15	0.932	1.020	1.020	1.07	0.98	0.914
Tap36	0.968	0.988	1.012	0.99	0.96	0.906
QC10	0.19	0.077	0.077	0.19	0.19	0.089
QC24	0.043	0.119	0.128	0.04	0.04	0.101
PG (MW)	300.9	299.54	299.54	NR*	NR*	298.59
QG (Mvar)	133.9	130.83	130.94	NR*	NR*	131.81
Reduction in PLoss (%)	0	8.4	7.4	6.6	8.3	10.05
Total PLoss (Mw)	17.55	16.07	16.25	16.38	16.09	15.786

NR - Not reported.*

5. Conclusion

In this paper Gryllidae Optimization Algorithm (GOA) successfully solved the optimal reactive power problem. Application of the Gryllidae Optimization Algorithm is developed by the inspiration of a type of insect; on the recognizable global engineering problems in the simulation-based nature which has recently participated to the meta-heuristic algorithm approach was confirmed. Proposed Gryllidae Optimization Algorithm (GOA) has been tested in standard IEEE 14, 30 bus test systems and simulation results show that the projected algorithms reduced the real power loss considerably.

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