Active Power Loss Reduction by Novel Feral Cat Swarm Optimization Algorithm

Submitted: 16th May 2019; accepted: 3rd April 2020

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DOI: 10.14313/JAMRIS/2-2020/16

Abstract: *In this paper Feral Cat Swarm Optimization (FCS) Algorithm is proposed to solve optimal reactive power problem. Projected methodology has been modeled based on the activities of the feral cats. They have two main phases primarily "seeking mode", "tracing mode". In the proposed FCS algorithm, population of feral cats are created and arbitrarily scattered in the solution space, with every feral cat representing a solution. Produced population is alienated into two subgroups. One group will observe their surroundings which come under the seeking mode and another group moving towards the prey which will come under the tracing mode. New-fangled positions, fitness functions will be calculated subsequent to categorization of feral cats for seeking mode and tracing mode, through that cat with the most excellent solution will be accumulated in the memory. Feral Cat Swarm Optimization (FCS) Algorithm has been tested in standard IEEE 30 bus test system and simulation results show the projected algorithm reduced the real power loss considerably.*

Keywords: *optimal reactive power, Transmission loss, Feral Cat Swarm Optimization Algorithm*

1. Introduction

Reactive power problem plays a significant role in secure and economic operations of power system. Various methods [1-6] have been utilized to solve the optimal reactive power problem. Nevertheless several scientific difficulties are found due to an assortment of constraints. Evolutionary techniques [7-16] are applied to solve the reactive power problem. This paper proposes Feral Cat Swarm Optimization (FCS) Algorithm to solve optimal reactive power problem. Proposed approach has been modeled based on the deeds of the feral cats. They had two phases called as "seeking mode", "tracing mode". In the projected FCS algorithm, population formed and capriciously dispersed in the solution space, with every feral cat symbolize a solution. Engendered population is alienated into two subgroups. One group will keep an eye on their surroundings which comes under the seeking mode and another group moving towards the prey which comes under the tracing mode. Subsequent to discovery of the prey although in latent mode (seeking mode), feral cat make a decision for quick movement and a way based on the prey's location and progression. Normally cats use diminutive time in tracing mode, so in the subgroup of tracing mode must be small. By means of the mixture ratio (MR) it has been defined. New-fangled positions, fitness functions will be calculated subsequent to categorization of feral cats for seeking mode and tracing mode, through that cat with the most excellent solution will be accumulated in the memory. Until the end criterion reached these steps are repeated. Proposed Feral Cat Swarm Optimization (FCS) Algorithm has been tested in standard IEEE 30 bus test system and simulation results show the projected algorithm reduced the real power loss effectively.

2. Problem Formulation

Reduction real power loss is the objective function of the problem and mathematically written as

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

with reference to voltage deviation it has been written as

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

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

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. Feral Cat Swarm Optimization Algorithm

Feral Cat Swarm Optimization (FCS) Algorithm has been modeled based on the deeds of the feral cats. They had two phases mainly "seeking mode", "tracing mode". In the projected FCS algorithm, population of feral cats are formed and capriciously dispersed in the solution space, with every feral cat indicating a solution. Engendered population is alienated into two subgroups; one group will keep an eye on their surroundings which comes under the seeking mode and another group moving towards the prey which come under the tracing mode. Normally cats use diminutive time in tracing mode, so in the subgroup of tracing mode must be small. By means of the mixture ratio (MR) it has been defined [17]. New-fangled positions, fitness functions will be calculated subsequent to categorization of feral cats for seeking mode and tracing mode, through that cat with the most excellent solution will be accumulated in the memory. Until the end criterion reached these steps are repeated.

Seeking Mode; During this mode the feral cat is resting condition but keeping an eye on the surroundings. Feral cat make a decision for its subsequent move when there is any danger or prey found. Four parameters are used in the modeling [17]: seeking memory pool (SMP; sum of the copies organized of every cat in the seeking procedure), seeking range of the selected dimension (SRD; highest difference between the new-fangled and old values in the dimension chosen for mutation), counts of dimension to change (CDC; number of dimensions will be mutated), and self-position consideration (SPC; Boolean variable which point out the present position of the cat as a candidate position for movement) [17].

Step a. Construct SMP replica of each feral cati. When SPC has true value, SMP-1 copies are formed and present position of the feral cat be as one among the copies made.

Step b. With reference to CDC compute a new-fangled position for each copy by the following equation,

$$Y_{cn} = \left(1 \pm SRD \times R\right) \times Y_c \tag{10}$$

Y_{cn} – indicate the new fangled position; Y_c – present positions; R – random number.

Step c. Calculate the fitness values (FS) for new-fangled positions. For all candidate points When FS values are precisely equal for all then fix selecting probability as 1. Or else compute the selecting probability of every candidate point by using Equation (11).

Step d. By utilizing roulette wheel, arbitrarily choose the point to shift from the candidate points, and swap the position of feral cati.

$$P_i = \frac{\left|FS_i - FS_b\right|}{\left|FS_{maximum} - FS_{minimum}\right|} \quad 0 < i < j \tag{11}$$

P_i – probability of present candidate feral cati; FS_i – feral cati fitness value; FS_{max} fitness function maximum value; FS_{min} fitness function minimum value; $FS_b = FS_{max}$ for optimal reactive power problem (minimization problem)

Tracing Mode; it simulates action of the feral cat hunting the prey. Subsequent to discovery of the prey although in latent mode (seeking mode), feral cat make a decision for movement speed and way based on the prey's location and speed

$$vl_{k,d} = vl_{k,d} + r_1 \times c_1 \left(Y_{best,d} - Y_{k,d}\right) \tag{12}$$

By means of velocity, the feral cat progress in the decision space and it informs about each new-fangled position it acquires. When the velocity of the feral cat is superior to the highest velocity- it will be fixed as maximum velocity. Then the new-fangled position of each feral cat is calculated by

$$Y_{k,d,new} = Y_{k,d,old} + vl_{k,d} \tag{13}$$

A new-fangled modified search equation is projected for tracing mode

$$Y_{k,d,new} = \left(1 - \beta\right) * Y_{k,d} + \beta * P_g + vl_{k,d} \tag{14}$$

$Y_{k,d,new}$ – Most excellent position attained by k^{th} cat in dth dimension, $Y_{k,d}$ – present position of the k^{th} cat in dth dimension, $vl_{k,d}$ old velocity of the k^{th} cat.

To perk up the diversity of the projected algorithm, particularly in tracing mode, a new-fangled velocity modernized equation is proposed as,

$$Y_{k,d,new} = vl_{k,d} + \beta\left(P_g - Y_{k,d}\right) + \alpha * \varepsilon \tag{15}$$

α and β perform as control parameters to balance the exploration and exploitation procedure

$$\alpha(t) = \alpha_{\max} - \left\{\frac{\alpha_{\max} - \alpha_{\min}}{t_{\max}}\right\} * t \tag{16}$$

$$\beta(t) = \beta_{\min} + \left(\beta_{\max} - \beta_{\min}\right) \sin\left\{\frac{\pi t}{t_{\max}}\right\} \tag{17}$$

In this projected algorithm local search method has been implemented in order to direct the exploring direction and to attain the optimum solution in exploration space. Local optima problem has been avoided by collecting the neighborhood information. Exploring mechanism is employed to the present global best solution (Y_{gbest}), and then the neighborhood of best solution can be described by

$$\left[Y_{gb}\right] = \left[Y_{gbest} - r, Y_{gbest} + r\right]^n \tag{18}$$

r – boundary of neighborhood, Y_{gb} – present most excellent solution, n – population number

Local search method will go to all N number of populations in all iterations

$$Y_{gb}^L(k) = \begin{cases} Y_{gb}^L(k-1) d \neq L \\ Y_{gb}^L(k-1) + r * cx^d d = L \end{cases} \tag{19}$$

Most excellent agent during the exploration can be selected in all iterations by

$$Y_{gb}(k) = \text{Minimum}\left\{Y_{gb}^1(k), \ldots, Y_{gb}^L(k), \ldots, Y_{gb}^n(k)\right\} \tag{20}$$

Procedure of Feral Cat Swarm Optimization Algorithm

Step 1. Engender the preliminary population of feral cats and scatter them in the solution space ($y_{i,d}$) and capriciously allocate velocity in the range to maximum velocity value $vl_{i,d}$ for each feral cat.

Step 2. Allocate a flag to each feral cat in order to sort them into the seeking, tracing phase assign each cat a flag to sort them into the seeking or tracing mode process with reference to the mixture ratio (MR).

Step 3. By computation of the fitness value of each feral cat then the feral cat with most excellent fitness function is found and it will be saved. Position of the most excellent cat (Ybest) symbolizes the most excellent solution so far obtained.

Step 4. Apply the cats into the seeking, tracing phase based on their flags.

Step 5. Employ the Local search procedure

Step 6. modernize the position of feral cats and global position

Step 7. If the end criteria is satisfied, then stop the procedure or else replicate the step from 2 to 5.

Commence
Initialization of the parameters
Feral cat population, SPC are initialized
While (end criterion is not reached or I < Imax)
For all feral cats compute the fitness function values and classify them
Y_g = feral cat with the most excellent solution
For = 1: N
If SPC = 1 then commence the seeking mode
Or Else commence the tracing mode
Apply the Local search procedure
Renew the position of feral cats and global position
End if
End for "i"
End while
Output the results
End

4. Simulation Study

Feral Cat Swarm Optimization (FCS) Algorithm has been tested in standard IEEE 30 Bus system [18]. 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. Figure 1 gives the Comparison of real power loss and Figure 2 gives the Reduction of real power loss (%) with reference to base case value.

Tab. 1. Constraint values of the control variables

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

Tab. 2. Constrains values of the reactive power generators

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

Tab. 3. Simulation results of IEEE – 30 system

List of Control variables	Base case value	MPSO [19]	PSO [19]	EP [19]	SARGA [19]	FCS
VG–1	1.060	1.101	1.100	NR*	NR*	1.018
VG–2	1.045	1.086	1.072	1.097	1.094	1.039
VG–5	1.010	1.047	1.038	1.049	1.053	1.010
VG–8	1.010	1.057	1.048	1.033	1.059	1.018
VG–12	1.082	1.048	1.058	1.092	1.099	1.027
VG-13	1.071	1.068	1.080	1.091	1.099	1.032
Tap-11	0.978	0.983	0.987	1.01	0.99	0.940
Tap-12	0.969	1.023	1.015	1.03	1.03	0.911
Tap-15	0.932	1.020	1.020	1.07	0.98	0.904
Tap-36	0.968	0.988	1.012	0.99	0.96	0.916
QC-10	0.19	0.077	0.077	0.19	0.19	0.094
QC-24	0.043	0.119	0.128	0.04	0.04	0.108
PG (MW)	300.9	299.54	299.54	NR*	NR*	298.19
QG (Mvar)	133.9	130.83	130.94	NR*	NR*	130.27
Reduction in PLoss (%)	0	8.4	7.4	6.6	8.3	19.18
Total PLoss (Mw)	17.55	16.07	16.25	16.38	16.09	14.183

NR* – Not reported.

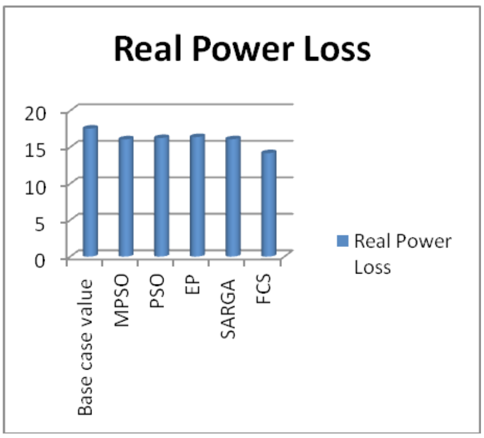

Fig. 1. Comparison of real power loss

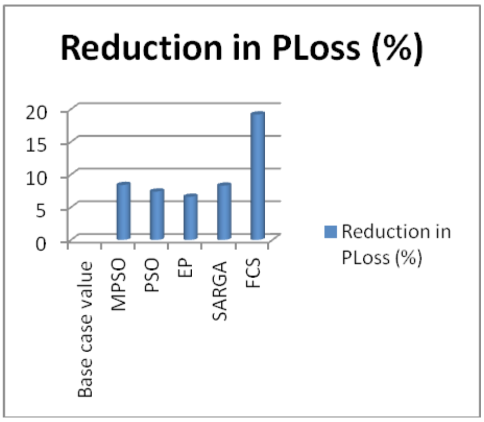

Fig. 2. Reduction of real power loss (%) with reference to base case value

5. Conclusion

In this work optimal reactive power problem has been solved by Feral Cat Swarm Optimization (FCS) Algorithm in efficient mode. In the projected FCS algorithm, population of feral cats are formed and capriciously dispersed in the solution space, with every feral cat indicated a solution. New-fangled positions, fitness functions will be calculated subsequent to categorization of feral cats for seeking mode and tracing mode, through that cat with the most excellent solution will be accumulated in the memory. Proposed Feral Cat Swarm Optimization (FCS) Algorithm has been tested in standard IEEE 30 bus test system and simulation results show the projected algorithm reduced the real power loss considerably. Around 19.18 % reduction of real power loss have been attained.

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