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Factual Power Loss Diminution by Enhanced Frog Leaping Algorithm

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Abstract

This paper proposes Enhanced Frog Leaping Algorithm (EFLA) to solve the optimal reactive power problem. Frog leaping algorithm (FLA) replicates the procedure of frogs passing though the wetland and foraging deeds. Set of virtual frogs alienated into numerous groups known as "memeplexes". Frog's position's turn out to be closer in every memeplex after few optimization runs and certainly, this crisis direct to premature convergence. In the proposed Enhanced Frog Leaping Algorithm (EFLA) the most excellent frog information is used to augment the local search in each memeplex and initiate to the exploration bound acceleration. To advance the speed of convergence two acceleration factors are introduced in the exploration plan formulation. Proposed Enhanced Frog Leaping Algorithm (EFLA) has been tested in standard IEEE 14,300 bus test system and simulation results show the projected algorithm reduced the real power loss considerably.

Keywords: Optimal Reactive Power, Transmission loss, Frog leaping 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 [7-16] are applied to solve the reactive power problem. This paper proposes an Enhanced Frog Leaping Algorithm (EFLA) to solve the optimal reactive power problem. Frog leaping algorithm (FLA) replicates the procedure of frogs passing though the wetland and foraging deeds. F frogs are engendered at initial to structure a group, in which frog i of the group is symbolized as $X_i = (x_i^1, x_i^2, \ldots, x_i^N)$ then individual frogs in the group are arranged in downhill order with reference to the fitness values, in order to discover the global most excellent solution. In the proposed Enhanced Frog Leaping Algorithm (EFLA) the most excellent frog information is used to augment the local search in each memeplex and initiate to the exploration bound acceleration. To advance the speed of convergence two acceleration factors are introduced in the exploration plan formulation. Proposed Enhanced Frog Leaping Algorithm (EFLA) has been tested

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in standard IEEE 14,300 bus test system and simulation results show the projected algorithm reduced the real power loss considerably.

2. Problem Formulation

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

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

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)

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

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

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

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

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

3.Enhanced Frog leaping algorithm

Frog leaping algorithm (FLA) replicates the procedure of frogs passing though the wetland and foraging deeds. F frogs are engendered at initial to structure a group, in which frog i of the group is symbolized as $X_i = (x_i^1, x_i^2, \ldots, x_i^N)$ then individual frogs in the group are arranged in downhill order with reference to the fitness values, in order to discover the global most excellent solution [17]. Groups are alienated into m ethnic groups, and each group structured with n frogs, filling the relation F = m × n. regulation of ethnic group division is formulated as : first frog placed in the first sub-group, second frog placed in the second sub-group, frog m placed in the sub-group m, frog m + 1placed in the first sub-group again, frog m + 2 placed in the second sub-group; this alienation carried out, till all the frogs are alienated. After that the most excellent frog in each sub-group, has to be found out and indicated by P_b; poor frog indicated by P_w.

$$D = random() * (P_b - P_\omega) \tag{10}$$

$$P_{new-\omega} = P_\omega + D_i, -D_{max} \leq D_i \leq D_{max} \tag{11}$$

When the modernized $P_{new-\omega}$ is in the viable solution spaces then calculate the analogous fitness value of $P_{new-\omega}$. When the related fitness value of $P_{new-\omega}$ is poorer than the analogous fitness value of P_w, afterwards apply P_w to swap P_b in equation (10) and re-modernize $P_{new\ -\omega}$; after then also no development, then capriciously engender a new-fangled frog to swap P_w; replicate the modernizing procedure until fulfilling end criterion

a. Produce capriciously the population of frogs
b. Fitness value of each frog has been calculated by its position.
c. Partition of the population will done into m memeplexes in the groups
d. For a definite number of evolutionary iterations each memeplex has to be developed. Subsequently algorithm proceeds to the global exploration to shuffle memeplexes.
e. Categorize most excellent and poor frog.
f. Perk up the poor frog's position; $D = \mathrm{rand}() * (P_b - P_\omega)$; new-fangled position found by $D = \mathrm{rand}() * (P_b - P_\omega)$. When this method creates an improved solution, then it swaps the poor frog. or else, go to the subsequent step.
g. Reiterate the calculation in (10) and (11) when no improvements then go to subsequent step.
h. Engender a new-fangled random solution to swap the poor frog and repeat the procedure for a predefined number of times.
i. After a definite number of memetic evolutionary steps within every memeplex Shuffle the memeplexes. Then arrange the frogs in a downhill order with reference to the fitness value.
j. If the end criterion is reached then stop or else go to Step c.

Many times Frog leaping algorithm (FLA) falls into the local optimal solution particularly with respect to the problem complexity. Mainly deliberation of the whole population positions around a local optimum and it cause an early stagnation of the algorithm. In order to overcome this situation, an exploration acceleration factor has been induced as follows,

$$D = random() * C * (P_b - P_\omega) \tag{12}$$

Exploration acceleration factor "C" permit a greater change in frog's position and thus, will broaden the global exploration area at the commencement and focus the memetic evolution on a deeper local exploration in the region of the optimal solution. In the proposed Enhanced Frog Leaping Algorithm (EFLA) alter the position of frogs in a memeplex is done. As an alternative of moving only the poor frogs, most excellent frogs are also moved to execute a local exploration and perk up their performance. Every most excellent frog has the identical scheme of altering its position as poor frogs does in the Frog leaping algorithm.

i. Categorize the most excellent and the poor frog
ii. Previous to estimation of the poor frog's position, perk up the most excellent frog is tried with the intention of make sure of enhanced convergence of the memeplex which leads to superior solutions. Enhancement of the most excellent frog's position is attained by,

$$D = C_1 * random() * (P_b - P_\omega) \tag{13}$$

New-fangled position can be found by,

$$xb_{id}^{n+1} = xb_{id}^{n} + D \tag{14}$$

iii. Improvement the poor frog's position is done through,

$$D = C_2 * random() * (P_b - P_\omega) \tag{15}$$

New-fangled position can be found by,

$$x\omega_{id}^{n+1} = x\omega_{id}^{n} + D \tag{16}$$

iv. Reiterate the calculation in (15) and (16) with respect to the global most excellent frog. When there is no enhancement then go to the subsequent step.
v. Engender a new-fangled capricious solution to swap the poor frog

Proposed Enhanced Frog Leaping Algorithm (EFLA) where the alteration in the 'memetic evolution' has been done which leads to improve the efficiency of the algorithm.

a. Produce capriciously the population of frogs
b. Fitness value of each frog has been calculated by its position.
c. Partition of the population will done into m memeplexes in the groups
d. For a definite number of evolutionary iterations each memeplex has to be developed. Subsequently algorithm proceeds to the global exploration to shuffle memeplexes.
e. Categorize most excellent and poor frog.
   Previous to estimation of the poor frog's position, perk up the most excellent frog is tried with the intention of make sure of enhanced convergence of the memeplex which leads to superior solutions. Enhancement of the most excellent frog's position is attained by; $D = C_1 * random() * (P_b - P_\omega)$
   New-fangled position can be found by; $xb_{id}^{n+1} = xb_{id}^{n} + D$; Improvement the poor frog's position is done through; $D = C_2 * random() * (P_b - P_\omega)$; New-fangled position can be found by; $x\omega_{id}^{n+1} = x\omega_{id}^{n} + D$. Reiterate the calculation with respect to the global most excellent frog. When there is no enhancement then go to the subsequent step. Engender a new-fangled capricious solution to swap the poor frog.
f. After a definite number of memetic evolutionary steps within every memeplex Shuffle the memeplexes. Then arrange the frogs in a downhill order with reference to the fitness value.
g. If the end criterion is reached then stop or else go to Step c.

4.Simulation Results

At first in standard IEEE 14 bus system the validity of the Projected Enhanced Frog Leaping Algorithm (EFLA) has been tested & comparison results are presented in Table 1.

Table 1. comparison of loss

Control variables	ABCO [19]	IABCO [19]	EFLA
V1	1.06	1.05	1.02
V2	1.03	1.05	1.01
V3	0.98	1.03	1.03
V6	1.05	1.05	1.00
V8	1.00	1.04	0.90
Q9	0.139	0.132	0.100
T56	0.979	0.960	0.900
T47	0.950	0.950	0.900
T49	1.014	1.007	1.000
Ploss (MW)	5.92892	5.50031	4.0192

Then IEEE 300 bus system [18] is used as test system to validate the performance of the Enhanced Frog Leaping Algorithm (EFLA). Table 2 shows the comparison of real power loss obtained after optimization.

Table 2 Comparison of Real Power Loss

Parameter	Method EGA [21]	Method EEA [21]	Method CSA [20]	EFLA
PLOSS (MW)	646.2998	650.6027	635.8942	617.0928

5.Conclusion

Enhanced Frog Leaping Algorithm (EFLA) successfully solved the optimal reactive power problem. In the proposed Algorithm the most excellent frog information is used to augment the local search in each memeplex and initiate to the exploration bound acceleration. To advance the speed of convergence two acceleration factors are introduced in the exploration plan formulation. Proposed Enhanced Frog Leaping Algorithm (EFLA) has been tested in standard IEEE 14,300 bus test system and simulation results show the projected algorithm reduced the real power loss considerably.

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