Factual Power Loss Reduction by Amplified Bat Algorithm

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***Abstract*; In this paper,** Amplified Bat Algorithm (ABA) is projected to solve optimal reactive power problem. Proposed algorithm reproduces the actions of the Bat actions and it uses sonar echoes to notice and stay away from obstacle. To maintain the balance between the local and global search ability, a new-fangled search equation is projected for each bat based on the record of the optimal position that it memorized; to stay away from falling into a local optimal solution, an unique mechanism is implemented for each bat based on the number of its position and to augment the local search capability, a dynamic adaptive explore equation is defined. Proposed Amplified Bat Algorithm (ABA) has been tested in standard IEEE 14,300 bus test system and simulation results show the projected algorithm reduced the real power loss considerably.

Key words; optimal reactive power, Transmission loss, Bat 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 Amplified Bat Algorithm (ABA) to solve optimal reactive power problem. Proposed algorithm Imitate the deeds of the Bat actions and it uses sonar echoes to notice and stay away from obstacle. Time delay is used from emission to reflection and employing it for direction-finding. Echolocation used as main part to sense the distance and for other activities. With velocity ϑ_i at position x_i with a set frequency f_{min}, changeable wavelength λ and loudness A_0 Bats fly arbitrarily to look for the prey. Wavelength can be adjusted automatically and can regulate the rate of pulse emission r ∈ [0; 1], depend on the propinquity of the target. In the bat algorithm chaotic disturbance is introduced. At this juncture variance σ^2 show the converge degree of all particles. To maintain the balance between the local and global search ability, a new-fangled search equation is projected for each bat based on the record of the optimal position that it memorized; to stay away from falling into a local optimal solution, an unique mechanism is implemented for each bat based on the number of its position and to augment the local search capability, a dynamic adaptive explore equation is defined. Proposed Amplified Bat Algorithm (ABA) has been tested 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:

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

Voltage deviation given as follows:

$$\mathbf{F = P_L + \omega_v \times Voltage\ Deviation} \quad (2)$$

Voltage deviation given by:

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

Constraint (Equality)

$$\mathbf{P_G = P_D + P_L} \quad (4)$$

Constraints (Inequality)

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

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

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

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

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

3. Amplified Bat Algorithm

Bat algorithm imitated the deeds of the Bat actions and it uses sonar echoes to notice and stay away from obstacle. Time delay is used from emission to reflection and employing it for direction-finding. Echolocation used as main part to sense the distance and for other activities. With velocity ϑ_i at position x_i with a set frequency f_{min}, changeable wavelength λ and loudness A_0 Bats fly arbitrarily to look for the prey. Wavelength can be adjusted automatically and can regulate the rate of pulse emission r ∈ [0; 1], depend on the propinquity of the target [17]. Loudness assumed to vary from a large (positive) A_0 to minimum constant value A_{min}.

New solutions engendered by,

$$Q_i^{(t)} = Q_{min} + (Q_{max} - Q_{min}) \cup (0,1), \quad (10)$$
$$v_i^{(t+1)} = v_i^t + (x_i^t - best)Q_i^{(t)}, \quad (11)$$
$$x_i^{(t+1)} = x_i^{(t)} + v_i^{(t)} \quad (12)$$

For local search a capricious walk with direct exploitation is used to modernize the present most excellent solution by:

$$x^{(t)} = best + \epsilon A_i^{(t)}(2U(0,1) - 1) \quad (13)$$

ϵ - scaling factor, $A_i^{(t)}$- loudness. Depending on the pulse rate r_i and new-fangled solutions are accepted with some proximity local search will be commenced. When bat finds a prey rate of pulse emission r_i augments and loudness Ai diminished, which mathematically written by,

$$A_i^{(t+1)} = \alpha A_i^{(t)}, r_i^{(t)} = r_i^{(0)}[1 - \exp(-\gamma\epsilon)] \quad (14)$$

In this work an Amplified Bat Algorithm (ABA) is projected to solve the problem by suitable improvements in the modelling. In the bat algorithm chaotic disturbance is introduced. At this juncture variance σ^2 show the converge degree of all particles.

$$\sigma^2 = \sum_{i=1}^{N}\left[\left(f_i - f_{avg}\right)/f\right]^2 \quad (15)$$

$$f = max\left\{1, max\left\{\left|f_i - f_{avg}\right|\right\}\right\} \quad (16)$$

$$y_{id}(t+1) = \mu y_{id}(t)\left(1 - y_{id}(t)\right) \quad (17)$$

Population diversity will be amplified and to avert the premature convergence, an adaptive chaotic disturbance P_c is added at the time of stagnation. Thus, P_c is modified as P_c' .

$$p_{cd}'(t+1) = p_{cd}(t) + R_{id}\left(2_{yid}(t) - 1\right) \quad (18)$$

$$R_{id} = \beta\left|p_{cd}(t) - p_{id}(t)\right| \quad (19)$$

A modified velocity equation projected as,

$$v_i^{t+1} = \omega * v_i^t + \left(x_i^t - \frac{x^* + x_{pi}^*}{2}\right) * f_i \quad (20)$$

A new-fangled search equation for local search is projected as follows,

$$x_{new} = x^* + \varphi * (x^* - x_i) \quad (21)$$

An innovative position x_{new} can be engendered by,

$$x_{new} = (1-\omega) * x^* + \emptyset * (x^* - x_i) \quad (22)$$

a. Initialize a population
b. Set $x_{pi}^* = x_i (i = 1, .., M)$ and most excellent present solution has to be found x^*
c. While t ≤ Iteration maximum do
d. For i = 1 to M do
e. For j = 1 to n do
f. modernize the velocity of each bat by

$$Q_i^{(t)} = Q_{min} + (Q_{max} - Q_{min}) \cup (0,1)\,; \qquad v_i^{t+1} = \omega * v_i^t + \left(x_i^t - \frac{x^* + x_{pi}^*}{2}\right) * f_i$$

g. modernize the position of each bat by $x_i^{(t+1)} = x_i^{(t)} + v_i^{(t)}$
h. End for
i. If random > ri then choose a solution amongst of the most excellent solutions
j. Engender local solution in the region of most excellent solution. $x_{new} = x^* + \varphi * (x^* - x_i)$
k. End if
l. $if\ random < A_i\ and\ f(x_i) < f(x^*)$
m. $fix\ \ x^* = x_i$
n. Augment the value of r_i, diminish the value of A_i.
o. End if
p. If $f(x_i) < f(x_{pi}^*)$
q. $x_{pi}^* = x_i\ then\ fix\ L_i = 0$
r. Or Else $fix\ L_i = L_i + 1$
s. End if
t. End for
u. For i = 1 to M do
v. $if\ L_i = L$ then by $x_{new} = (1-\omega) * x^* + \emptyset * (x^* - x_i)$ engender novel position & swap x_i
w. End if
x. End for
y. t = t + 1
z. End while

4. Simulation Results

At first in standard IEEE 14 bus system the validity of the Projected Amplified Bat Algorithm (ABA) has been tested & comparison results are presented in Table 1.

Control variables	ABCO [19]	IABCO [19]	ABA
V1	1.06	1.05	1.00
V2	1.03	1.05	1.01
V3	0.98	1.03	1.04
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	4.1036

Then IEEE 300 bus system [18] is used as test system to validate the performance of the Projected Amplified Bat Algorithm (ABA).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]	ABA
PLOSS (MW)	646.2998	650.6027	635.8942	617.4310

5. Conclusion

Amplified Bat Algorithm (ABA) successfully solved the optimal reactive power problem. To maintain the balance between the local and global search ability, a new-fangled search equation is projected for each bat based on the record of the optimal position that it memorized; to stay away from falling into a local optimal solution, an unique mechanism is implemented for each bat based on the number of its position and to augment the local search capability, a dynamic adaptive explore equation is defined. Proposed Amplified Bat Algorithm (ABA) 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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