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Real power loss reduction by dolphin swarm algorithm

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ABSTRACT

In this work Spinner Dolphin Swarm Algorithm (SDSA) has been applied to solve the optimal reactive power problem. Dolphins have numerous remarkable natural distinctiveness and living behavior such as echolocation, information interactions, collaboration, and partition of labor. Merging these natural distinctiveness and living behavior with swarm intelligence has been modeled to solve the reactive power problem. Proposed Spinner Dolphin Swarm Algorithm (SDSA) has been tested in standard IEEE 14,300 bus test system and simulation results show the projected algorithm reduced the real power loss extensively.

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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 [7-16] 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. In this work Spinner Dolphin Swarm Algorithm (SDSA) has been applied to solve the optimal reactive power problem. The whole process of dolphin's predation consists of three stages. In the primary phase, every dolphin separately takes benefit of sounds to explore for close by preys and to assess the nearby environment using echoes. In the second phase, dolphins swap their information. When dolphins received information then it moves towards the prey and it has been surrounded by other dolphins. In the final phase, the prey is encircled by the dolphins to consume the food; it indicates that predation is accomplished. Proposed Spinner Dolphin Swarm Algorithm (SDSA) has been tested in standard IEEE 14,300 bus test system and simulation results show the projected algorithm reduced the real power loss extensively.

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)

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

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

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

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

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

3. SPINNER DOLPHIN SWARM ALGORITHM

Spinner Dolphin Swarm Algorithm (SDSA) is employed primarily by replicating the natural features and living behaviour by a dolphin. In this work $DOLPHIN_i = [x_1, x_2, .., x_D]^T \ i = (1,2, .., N)$, where N is the number of dolphins and $x_j (j = 1,2, .., D)$ component to be optimized [17].

Individual optimal solution (indicated as L) and neighbourhood optimal solution (indicated as K) are two variables connected with the dolphin. For each DOI_i (i=1, 2, …, N), there are two corresponding variables L_i (i=1, 2, …, N) and K*i* (i=1, 2, …, N), where Li symbolize the optimal solution that DOI_i finds in a distinct time and Ki the optimal solution of what DOI_i locate by itself.

In the proposed algorithm, there are three types of distances are utilized as in sum. The primary is the distance between DOI_i and DOI_J named $DD_{i,j}$ which is designed as follows

$$DD_{i,j} = \|DOI_i - DOI_J\| \ i, j = 1,2, .., N, i \ne j \quad (10)$$

$$DK_i = \|DOI_i - K_i\| \ i = 1,2, .., N \quad (11)$$

$$DKL_i = \|L_i - K_i\| \ i = 1,2, .., N \quad (12)$$

In exploration phase, every dolphin explores its close proximity area by creation of sounds towards M arbitrary directions

$$X_{ijt} = DOI_i + V_j t \quad (13)$$

Fitness value is computed as follows,

$$E_{ijt} = Filtness\ value\ (xjt) \quad (14)$$

When,

$$E_{iab} = Minimum_{j=1,2,..,M; t=1,2,..,T_1} E_{ijt} = Minimum_{j=1,2,..,M; t=1,2,..,T_1} Filtness\ value\ (xjt) \quad (15)$$

Individual solution is determined by

$$L_i = X_{iab} \quad (16)$$

$$Fitness\ value\ L_i < Fitness\ value\ K_i \quad (17)$$

$$TS_{i,j} = 0 \quad (18)$$

$$Fitness\ value\ K_i > Fitness\ value\ K_j \quad (19)$$

Transmission time matrix TS will be modernized as follows

$$TS_{i,j} > \left[\frac{DD_{i,j}}{A.speed}\right] \quad (20)$$

Modernized by

$$TS_{i,j} = \left[\frac{DD_{i,j}}{A.speed}\right] \quad (21)$$

Search radius is represented by

$$R_1 = T_1 \times speed \quad (22)$$

$$DK_i \leq R_1 \quad (23)$$

Encircling radius can be computed by

$$R_2 = \left(1 - \frac{2}{e}\right) DK_i\,, e > 2 \quad (24)$$

$$New\ DOI_i = K_i + \frac{DOI_i - K_i}{DK_i} R_2 \quad (25)$$

Updated value known by

$$DK_i > R_1 \quad (26)$$

$$DK_i \geq DKL_i \quad (27)$$

The encircling radius R_2 can be computed as follows

$$R_2 = \left[1 - \frac{\frac{DK_i}{Fitness\ value\ (K_i)} + \frac{DK_i - DKL_i}{Fitness\ value\ (L_i)}}{e.DK_i \frac{1}{Fitness\ value\ (K_i)}}\right] DK_i\,, e > 2 \quad (28)$$

$$R_2 = \left[1 - \frac{\frac{DK_i}{Fitness\ value\ (K_i)} - \frac{DK_i - DKL_i}{Fitness\ value\ (L_i)}}{e.DK_i \frac{1}{Fitness\ value\ (K_i)}}\right] DK_i\,, e > 2 \quad (29)$$

New-fangled positions of $New\ DOI_i$ after obtaining the encircling radius,

$$New\ DOI_i = K_i + \frac{Random}{\|Random\|} R_2 \quad (30)$$

$$DK_i < DKL_i \quad (31)$$

For new position the fitness value can be calculated by,

$$Fitness\ value(new\ DOI_i) < Fitness\ value\ K_i \quad (32)$$

Step 1: initialize arbitrarily and consistently engender the preliminary of dolphin swarm Dol = {Dol_1, Dol_2, …, Dol_N} in the D-dimensional space. Compute the fitness value for every dolphin, and acquire Fitness $value_K$ = {Fitness value $_{K,1}$, Fitness value $_{K,2}$, …, Fitness value $_{K,N}$}.
Step 2: commencement of loop
While the stop condition is not satisfied do

Step 2.1: exploration phase

$$E_{ijt} = fitness\ value\ (DOI_i + V_j t)$$

Fitness value $_L$={min{E_{1jt}}, min{E_{2jt}}, …, min {EN_{jt}}}

$$Fitness\ value_{K,i} = \begin{cases} Fitness\ value_{L,i}\ \ if\ fitness\ value\ _{L,i}\ < fitness\ value\ _{K,i} \\ Fitness\ value\ _{K,i}\ otherwise \end{cases}$$

Step 2.2: call phase

$$TS_{i,j} = \begin{cases} \left[\frac{DD_{i,j}}{A.speed}\right]\ if\ fitness\ value_{k,j} < fitness\ value_{k,i}\ and\ TS_{i,j} > \left[\frac{DD_{i,j}}{A.speed}\right] \\ TS_{i,j} otherwise \end{cases}$$

Step 2.3: reaction phase $TS_{i,j}$ reduce one unit time

$$Fitness\ value_{k,i} = \begin{cases} Fitness\ value_{k,j}\ if\ TS_{i,j} = 0\ and fitness\ value_{k,j} < fitness\ value_{k,i} \\ Fitnes\ value\ _{k,i}\ otherwise \end{cases}$$

Step 2.4: predation phase
Compute DK_i and DKL_i if $DK_i \leq R_l$

$$R_2 = \left(1 - \frac{2}{e}\right) DK_i\ , e > 2$$

Else if $DK_i \geq DKL_i$

$$R_2 = \left[1 - \frac{\frac{DK_i}{Fitness\ value\ (K_i)} + \frac{DK_i - DKL_i}{Fitness\ value\ (L_i)}}{e.DK_i \frac{1}{Fitness\ value\ (K_i)}}\right] DK_i\ , e > 2$$

Else,

$$R_2 = \left[1 - \frac{\frac{DK_i}{Fitness\ value\ (K_i)} - \frac{DK_i - DKL_i}{Fitness\ value\ (L_i)}}{e.DK_i \frac{1}{Fitness\ value\ (K_i)}}\right] DK_i\ , e > 2$$

End if
DOI_i gets a new-fangled position, compute its fitness value, and modernize Fitness value$_{K,i}$
End While
Output the most excellent one of Ki (i=1, 2, …, N)

4. SIMULATION RESULTS

At first in standard IEEE 14 bus system the validity of the proposed Spinner Dolphin Swarm Algorithm (SDSA) has been tested & comparison results are presented in Table 1.

Table 1. Comparison results of the proposed spinner dolphin swarm algorithm

Control variables	ABCO [18]	IABCO [18]	SDSA
V1	1.06	1.05	1.05
V2	1.03	1.05	1.02
V3	0.98	1.03	1.00
V6	1.05	1.05	1.03
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 [19] is used as test system to validate the performance of the Spinner Dolphin Swarm Algorithm (SDSA). Table 2 shows the comparison of real power loss obtained after optimization.

Table 2. Comparison of real power loss

Parameter	Method EGA [20]	Method EEA [20]	Method CSA [21]	SDSA
PLOSS (MW)	646.2998	650.6027	635.8942	613.1010

5. CONCLUSION

In this work Spinner Dolphin Swarm Algorithm (SDSA) has been successfully solved the optimal reactive power problem. The biological characteristics of spinner dolphin and its living behaviour have been imitated to model the algorithm; which are explore phase, call phase, reaction phase, and predation phase. Proposed Spinner Dolphin Swarm Algorithm (SDSA) has been tested in standard IEEE 14,300 bus test system and simulation results show the projected algorithm reduced the real power loss extensively.

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