Reduction of real power loss by white male deer mating based optimization algorithm

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ABSTRACT. *In this paper, mating behaviour of the white male deer has been formulated to solve the reactive power problem. How the white male deers form the harem & how it mates with hinds are imitated to formulate the algorithm called as white male deer mating based optimization algorithm (WMDM). Proposed white male deer mating based optimization algorithm (WMDM) has been tested in standard IEEE 30 bus system. Simulation results show clearly the better performance of the proposed WMDM algorithm in reduction of real power loss.*

RÉSUMÉ. *Dans cet article, l'accouplement sexuel du cerf mâle blanc a été formulé pour résoudre le problème de la puissance réactive. Comment les cerfs mâles blancs forment le harem et comment il s'accouplent avec des cerfs femelles sont imités pour formuler un algorithme appelé l'algorithme d'optimisation basé sur accouplement mâle de cerf blanc (WMDM). Le projet d'algorithme d'optimisation basé sur l'accouplement du cerf mâle blanc (WMDM) a été testé dans le système de bus standard IEEE 30. Les résultats de simulation montrent clairement la performance meilleure de l'algorithme WMDM proposé pour réduire la perte de puissance réelle*

KEYWORDS: *optimal reactive power, transmission loss, white deer, swarm optimization.*

MOTS-CLÉS: *puissance reactive optimale, perte de transmission, cerf blanc, optimisation par essaim.*

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1. Introduction

The main objective of optimal reactive power problem is to reduce the actual power loss (Caldera *et al*., 2018). Various techniques problem (Lee 1984; Deeb 1988; Bjelogrlic *et al*., 1990; Granville 1994; Grudinin 1998; Yan *et al*., 2006) have been utilized but have the complexity in handling constraints. Different types of evolutionary algorithms (Aparajita *et al*., 2015; Hu *et al*., 2010; Mahaletchumi *et al*., 2015; Sulaiman *et al*., 2015; Pandiarajan *et al*., 2016; Mahaletchumi *et al*., 2016; Rebecca *et al*., 2016) have been utilized in various stages to solve the problem (Gagliano *et al*., 2017). In this paper, mating behaviour of the white male deer has been formulated to solve the reactive power problem. How the white male deers form the harem & how it mates with hinds are imitated to formulate the algorithm called as white male deer mating based optimization algorithm (WMDM). Proposed (WMDM) has been tested in standard IEEE 30 bus system. & real power loss reduced with voltage profiles within the limits.

2. Problem formulation

To minimize the system real power loss,

$$P_{loss} = \sum_{\substack{k=1 \\ k=(i,j)}}^{n} g_{k(V_i^2 + V_j^2 - 2V_i V_j \cos\theta_{ij})} \quad (1)$$

Voltage deviation magnitudes (VD) is stated as Minimize

$$VD = \sum_{k=1}^{nl} |V_k - 1.0| \quad (2)$$

Load flow equality constraints are:

$$P_{Gi} - P_{Di} - V_{i\sum_{j=1}^{nb} V_j} \begin{bmatrix} G_{ij} & \cos\theta_{ij} \\ +B_{ij} & \sin\theta_{ij} \end{bmatrix} = 0, i = 1,2 \ldots., nb \quad (3)$$

$$Q_{Gi} - Q_{Di} - V_{i\sum_{j=1}^{nb} V_j} \begin{bmatrix} G_{ij} & \sin\theta_{ij} \\ +B_{ij} & \cos\theta_{ij} \end{bmatrix} = 0, i = 1,2 \ldots., nb \quad (4)$$

Inequality constraints are:

$$V_{Gi}^{min} \leq V_{Gi} \leq V_{Gi}^{max}, i \in ng \quad (5)$$

$$V_{Li}^{min} \leq V_{Li} \leq V_{Li}^{max}, i \in nl \quad (6)$$

$$Q_{Ci}^{min} \leq Q_{Ci} \leq Q_{Ci}^{max}, i \in nc \quad (7)$$

$$Q_{Gi}^{min} \leq Q_{Gi} \leq Q_{Gi}^{max}, i \in ng \quad (8)$$

$$T_i^{min} \leq T_i \leq T_i^{max}, i \in nt \quad (9)$$

$$S_{Li}^{min} \le S_{Li}^{max}, i \in nl \tag{10}$$

3. White male deer mating based optimization algorithm

In the formulation of the algorithm the dimension of the reactive power problem is represented as N_{var}, a white deer is a, $1 \times N_{var}$ array. And this array can be articulated by,

$$\text{white deer} = \left[Y_1, Y_2, Y_3, .., Y_{N_{var}}\right] \tag{11}$$

For each white deer functional value can be calculated by

$$\text{functional value} = f(\text{white deer}) = f(Y_1, Y_2, Y_3, .., Y_{N_{var}}) \tag{12}$$

Population ($N_{population}$) is initiated, best white deers are nominated as N_{male} & others are designated as N_{hind}. Usually white male deers will attract the females through loud noise alike to roaring. Most dominant white male deer will replace the previous dominant one in the objective function & updating will be done periodically. Among the white male deers classification can be done as male leader & stags. The number of white male leaders can be drafted & correlated to $'\alpha'$ as,

$$\text{N.male.leader} = \text{round}\{\alpha . N_{male}\} \tag{13}$$

Where N.male.leader is the number of white male deer commander that seizing the horns. Once best white male deers are selected and others are called as stags,

$$\text{N.stag} = N_{male} - \text{N.male.leader} \tag{14}$$

Where N.stag number of stag in white male deer population. In this process each white male deers will fight with stags arbitrarily. Objective function is updated with the best white male deers after the fight. Depending on the strength of the white male deer leader a group of hinds will be formed under the one white male leader & it called as harems. The harems will be formed by the number of white male deer leaders & standardized value of the white male deer is found by,

$$Q_n = q_n - \max\{q_i\} \tag{15}$$

Where q_n is the value of nth white male deer &Q_n is the standardized value. The standardized power of each white male leader is found by,

$$QP_n = \left|\frac{Q_n}{\sum_{i=1}^{\text{N.male.leader}} Q_i}\right| \tag{16}$$

In a harem number of hinds can be calculated by,

$$\text{N.harem}_n = \text{round}\{QP_n . N_{hind}\} \tag{17}$$

Where $\mathrm{N.harem_n}$ is total number of hinds in harem and $\mathrm{N_{hind}}$ defines about number of all hinds available. Alike in genetic algorithm after mating, the offspring's are new solution & White male deer leader will mate with hinds & it has been correlated to β & can be written as,

$$\mathrm{N.harem_n^{mate}} = \mathrm{round}\ \{\beta.\mathrm{N.harem_n}\} \tag{18}$$

$\mathrm{N.harem_n^{mate}}$ Indicates the numbers of hinds are ready to mate with white male deer leader. In a harem the number of hinds mating with one white male deer leader is given by,

$$\mathrm{N.harem_n^{mate}} = \mathrm{round}\ \{\gamma.\mathrm{N.harem_n}\} \tag{19}$$

Then the distance between the all hinds & white male deer is formulated by,

$$\mathrm{T_i} = \left(\sum_{j\in J}\left(\mathrm{stag_j} - \mathrm{hind_j^i}\right)^2\right) \tag{20}$$

Roulette wheel selection method is used for selection next generation & stopping criteria is based on the best solution found.

Algorithm

Initialization of white deer's arbitrarily on the function

Leading high loud noise making white male deer's are found

White male deer leaders are selected based on α value

Stags & white male deer leaders will fight

Harems are formed with grouping of hinds

White male deer leader will mate with β percent of the hinds in their respective harem

White male deer leader will mate with γ percent of the hinds in another harem

Stag with mate with hind which is nearest to it

Next generation will be selected by Roulette wheel selection method

Stop If end condition reached or else go back to step 2

4. Simulation results

Validity of the proposed white male deer mating based optimization algorithm (WMDM) has been verified by testing in standard IEEE 30-bus & In Table 1 Control variables limits are given.

Table 1. Primary variable limits

List of Variables	Minimum limit	Maximum limit	Type
Generator Bus	0.9500	1.100	Continuous
Load Bus	0.9500	1.0500	Continuous
Transformer-Tap	0.9000	1.100	Discrete
Shunt Reactive Compensator	-0.1100	0.3100	Discrete

In Table 2 gives the power limits of generator buses.

Table 2. Power limits of the generator buses

Bus	Pg	Pgminimum	Pgmaximum	Qgminimum	Qgmaximum
1	96.000	49.00	200.00	0.00	10.0
2	79.000	18.00	79.00	-40.00	50.00
5	49.000	14.00	49.00	-40.00	40.00
8	21.000	11.00	31.00	-10.00	40.00
11	21.000	11.0	28.0	-6.000	24.00
13	21.000	11.0	39.0	-6.000	24.00

Table 3 shows the values of control variables. Table 4 narrates the performance of the proposed algorithm. overall comparison of real power loss is given in Table 5.

Table 3. After optimization values of control variables

List of Control Variables	WMDM
V1	1.04140
V2	1.04190
V5	1.01170
V8	1.02200
V11	1.06320
V13	1.04120
T4,12	0.0000

T6,9	0.0100
T6,10	0.9000
T28,27	0.9100
Q10	0.1000
Q24	0.1000
Real power loss (MW)	4.2382
Voltage deviation	0.9076

Table 4. Performance of WMDM algorithm

Number of Iterations	29
Time taken in secs	8.78
Real power loss (MW)	4.2382

Table 5. Comparison of results

Technique	Real power loss (MW)
Method SGA (Wu *et al.*, 1998)	4.9800
Method PSO (Zhao et al., 2005)	4.92620
Method LP (Mahadevan et al., 2010)	5.9880
Method EP (Mahadevan et al., 2010)	4.9630
Method CGA (Mahadevan et al., 2010)	4.9800
Method AGA (Mahadevan et al., 2010)	4.9260
Method CLPSO (Mahadevan et al., 2010)	4.72080
Method HSA (Khazali et al., 2011)	4.76240
Method BB-BC (Sakthivel et al., 2013)	4.69000
Method MCS (Tejaswini et al., 2016)	4.872310
Proposed WMDM	4.2382

5. Conclusion

Reactive power problem has been successfully solved by white male deer mating based optimization algorithm (WMDM). Proposed white male deer mating based optimization algorithm (WMDM) has been tested in standard IEEE 30 bus test system. Simulation results show the better performance of the WMDM algorithm in reduction of real power loss.

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