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Reduction of real power loss by upgraded red shaver swarm optimization algorithm

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ABSTRACT

In this paper, an upgraded Red Shaver swarm Optimization (RS) algorithm is proposed for solving reactive power problem. Under cockerel as group-mate Red Shaver explores food; also it prevents the same ones to eat their own food. Red Shaver would arbitrarily pinch the high-quality food which has been already found by other Red Shaver & always overriding other individuals to grab more food. In the Projected upgraded Red Shaver swarm Optimization (RS) algorithm additional parameters of cockerel, hens and chicks are eliminated, in order to upsurge the search towards global optimization solution. Proposed Upgraded Red Shaver swarm Optimization (RS) algorithm has been tested in standard IEEE 30 bus system. Simulation results show clearly the better performance of the proposed RS algorithm in reduction of real power loss.

1. INTRODUCTION

The main objective of optimal reactive power problem is to reduce the actual power loss. Various techniques [1-7] have been utilized but have the complexity in handling constraints. Different types of evolutionary algorithms [8-19] have been utilized in various stages to solve the problem. But many limitations have been found in Exploration & Exploitation. This paper proposes Upgraded Red Shaver swarm Optimization (RS) algorithm to solve reactive power problem. In this projected algorithm both exploration & exploitation has been augmented equally in order to reach near to global optimum solution. Red Shaver follows their cockerel to explore food. Overriding individuals have the lead to grab more food .In the region of the mother (hen [20]) Red shaver always searches for food. In the Projected Upgraded Red Shaver swarm Optimization (RS) algorithm additional parameters of cockerel, hens and chicks are eliminated, in order to upsurge the search towards global optimization solution. Proposed Upgraded Red Shaver swarm Optimization (RS) algorithm has been tested in standard IEEE 30 bus system. & real power loss reduced with voltage profiles within the limits.

2. PROBLEM FORMULATION

The key objective of the reactive power problem is to minimize the system real power loss & is given as,

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

where n is the number of transmission lines, gk is the conductance of branch k, Vi and Vj are voltage magnitude at bus i and bus j, and θij is the voltage angle difference between bus i and bus j.

Minimization of Voltage Deviation

voltage deviation magnitudes (VD) is stated as follows,

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

where nl is the number of load busses and V_k is the voltage magnitude at bus k.

System Constraints

Objective function has the following constraints as given below,

Load flow equality constraints:

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

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

Inequality constraints are:

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

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

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

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

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

$$S_{Li}^{min} \le S_{Li}^{max}, i \in nl \quad (10)$$

3. RED SHAVER SWARM OPTIMIZATION ALGORITHM

Red Shaver swarm Optimization based on the Red Shaver behaviour & it can be articulated mathematically as follows.

$$y_{i,j}^{t+1} = y_{i,j}^{t} * \left(1 + Rand(0,\sigma^2)\right) \quad (11)$$

$$\sigma^2 = \begin{cases} 1 & ft_i \leq ft_k \\ exp\left(\frac{ft_k - ft_i}{|ft_i + \varepsilon|}\right) & other\ wise \end{cases} \quad k \in [1,N], k \neq 1 \quad (12)$$

where $Rand(0,\sigma^2)$is a Gaussian distribution with mean 0 and standard deviation σ^2.

Dominant hens competing for food highly & formulated mathematically as follows,

$$y_{i,j}^{t+1} = y_{i,j}^{t} + G1 * Rand * \left(y_{r^1,j}^{t} - y_{i,j}^{t}\right) + G2 * Rand * \left(y_{r^2,j}^{t} - y_{i,j}^{t}\right) \quad (13)$$

$$G1 = exp\left(\frac{ft_i - ft_{r^1}}{abs(ft_i) + \varepsilon}\right) \quad (14)$$

$$G2 = exp(ft_{r^2} - ft_i) \quad (15)$$

where Rand is a uniform random number over $r^1 \in$ [0, 1], is an index of the cockerel, which is the ith hen's group-mate, while $r^2 \in$ [0, 1], is an index of the Red Shaver, which is arbitrarily chosen from the swarm $r^1 \neq r^2$.

Around the mother, chicks move to forage for food & formulated by,

$$y_{i,j}^{t+1} = y_{i,j}^{t} + FL * \left(y_{m,j}^{t} - y_{i,j}^{t}\right) \quad (16)$$

where $y_{m,j}^{t}$, stands for the position of the i-th chick's mother$m \in [1,N]$. FL[$FL \in (0,2)$].

4. UPGRADED RED SHAVER SWARM OPTIMIZATION ALGORITHM

In the up gradation of the Red shaver optimization algorithm the parameters are tuned in the Exploration & Exploitation Step. It will augment the search & lead to a better solution.

Initialization of Population

Red Shaver swarm population are initialized by,

$$y_{i,j} = lb + Rand(ub - lb) \quad (17)$$

In exploration space, lb and ub are lower bound and upper bound.

Exploration Step

Each individual of Red Shaver population revamp their position and it formulated as,

$$y_{i,j}(*) = y_{i,j} + G1 * Rand * \left(y_{l.j} - y_{i,j}\right) + G2 * Rand * \left(y_{n,j} - y_{i,j}\right) \quad (18)$$

With

$$G1 = exp\left(\frac{(ft_i - ft_l)}{|ft_i + \varepsilon|}\right) \quad (19)$$

$$G2 = exp(ft_n - ft_i) \quad (20)$$

$y_l, y_n \in [1,N]$is arbitrarily chosen form Red Shaver swarm with $y_i \neq y_l \neq y_n$.

Based on most excellent fitness value best individual of the global population is found & termed as $\left(y_{i,j}(g)\right)$

Exploitation Step

The first step in Local optimum search is reduction of cockerel formula as follows.

$$y_{i,j}(**) = y_{i,j}(g) * \left(1 + Rand(0,\sigma^2)\right) \quad (21)$$

$$\sigma^2 = \begin{cases} 1 & ft_i(g) \leq ft_l(g) \\ exp\left(\frac{ft_l(g) - ft_i(g)}{|ft_i(g) + \varepsilon|}\right) & other\ wise \end{cases} \quad l \in [1,N](g), l \neq i \quad (22)$$

Most excellent fitness value solution is chosen as best individual & called as Local population

I $\left(y_{i,j}(l_1)\right)$.

In concluding step of upgraded Red Shaver swarm optimization is to find more local optimum values as follows:

$$y_{i,j}(***) = y_{i,j}(l_1) + C * \left(y_{n,j}(l_1) - y_{i,j}(l_1)\right) \quad (23)$$

$y_n \in [1,N]$ is arbitrarily chosen from the local population I with $y_i \neq y_n$ and $C\left(C \in (0,2)\right)$.

Solution which has most outstanding fitness value is chosen as best individual & called as local population II$\left(y_{i,j}(l_2)\right)$. Until the stopping criterion is met this population is used as the preliminary population for the ensuing iterations.

Upgraded Red Shaver swarm Optimization (RS) algorithm for solving reactive power problem

a. By using equation (17) Initialize a population of N Red Shaver

b. N Red Shaver fitness value has been evaluated; $t = 0$

c. While $t < G$

d. For $i = 1; N$

aa. By equation (18) explore the global optimum & individual best global population$\left(y_{i,j}(g)\right)$

bb. Local optimum has been exploited.

aaa. By equation (21) find first local optimum & individual best local population I $\left(y_{i,j}(l_1)\right)$

bbb. By equation (23) find second local optimum & individual best local population II $\left(y_{i,j}(l_2)\right)$

e. End For

End While

5. SIMULATION RESULTS

Validity of the proposed Upgraded Red Shaver swarm Optimization (RS) algorithm has been verified by testing in standard IEEE 30-bus without considering Voltage stability evaluation. In Table 1 Control variables limits are given.

In Table 2 gives the power limits of generator buses. 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 1. Primary variable limits (PU)

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

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. After optimization values of control variables

List of Control Variables	RS
V1	1.04320
V2	1.04200
V5	1.01920
V8	1.02840
V11	1.06920
V13	1.04340
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)	4.2674
Voltage deviation	0.9070

Table 4. Performance of RS algorithm

Number of Iterations	25
Time taken in secs	9.68
Real power loss (MW)	4.2674

Table 5. Comparison of Results

List of Techniques	Real power loss (MW)
SGA [21]	4.98
PSO [22]	4.9262
LP [23]	5.988
EP [23]	4.963
CGA [23]	4.980
AGA [23]	4.926
CLPSO [23]	4.7208
HSA [24]	4.7624
BB-BC [25]	4.690
MCS [26]	4.87231
Proposed RS	4.2674

6. CONCLUSION

Reactive power problem has been successfully solved by Upgraded Red Shaver swarm Optimization (RS) algorithm & it eliminated the additional parameters of cockerel, hens and chicks, also upsurges the exploration in reaching the global optimization solution. Proposed Upgraded Red Shaver swarm Optimization (RS) algorithm has been tested in standard IEEE 30 bus test system. Simulation results show the better performance of the RS algorithm in reduction of real power loss.

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