

Reduction of Real Power Loss by Nature Inspired Algorithm

K.Lenin, B.RavindhranathReddy, and M.Suryakalavathi

Abstract- This paper presents American Buffalo algorithm (AB) to solve reactive power dispatch problem. AB algorithm imitates the American buffalo behaviour and their exploration techniques they utilize in the American forests and grasslands. The American buffalo employs its special intellectual, cooperative and independent approach in its exploration for the optimal path to reach the grassland. This endows it to get results faster than some other exploration agents. Proposed AB algorithm has been verified in standard IEEE 30 bus test system. Simulation results show evidently about the improved performance of the proposed algorithm in reducing the real power loss with control variables within the limits.

Index Terms— American buffalo, Optimization, Optimal reactive power, Transmission loss.

I.INTRODUCTION

UP to now various methodologies have been applied to solve the Optimal Reactive Power problem. The vital aspect of solving Reactive Power problem is to decrease the real power loss. Earlier several types of mathematical approaches like linear programming, gradient method (Alsac et al., 1973; Lee et al., 1985; Monticelli et al., 1987; Deeb et al., 1990; Hobson, 1980; Lee et al., 1993; Mangoli et al., 1993; Canizares et al., 1996) [1-8] has been used to solve the reactive power problem, but they lack in handling the constraints to reach a global optimization solution.

In the following level several types of evolutionary algorithms (Berizzi et al., 2012; Roy et al., 2012; Hu et al., 2010; Eleftherios et al., 2010) [9-12] has been applied to solve the reactive power problem. In this paper American Buffalo (AB) algorithm has been used to solve reactive power problem. American Buffalo algorithm is comprehensible, stout, operative, and proficient however simple to implement.

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It has noble ability in the exploitation and exploration of the search space. Efficiency of Proposed american buffalo (AB) algorithm has been verified by testing it in standard IEEE 30 bus test system. The simulation results reveals about the best performance of proposed algorithm in minimization of real power loss, when compared to other standard reported algorithms.

II.OBJECTIVE FUNCTION

A.Real power loss

The main objective of the reactive power dispatch problem is to reduce the real power loss and can be written in mathematically as follows:

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

Where F- objective function, P_L – power loss, g_k - conductance of branch, V_i and V_j are voltages at buses i, j , Nbr- total number of transmission lines in power systems.

B. Voltage profile augmentation

To decrease the voltage variation in PQ buses, the objective function (F) can be written mathematically as follows:

$$F = P_L + \omega_v \times VD \quad (2)$$

Where VD - voltage deviation, ω_v - is a weighting factor of voltage deviation.

And the Voltage deviation given by:

$$VD = \sum_{i=1}^{N_{pq}} |V_i - 1| \quad (3)$$

Where N_{pq} - number of load buses.

C. Equality Constraint

The equality constraint of the problem is given as power balance equation as follows:

$$P_G = P_D + P_L \quad (4)$$

Where P_G - total power generation, P_D - total power demand.

D. Inequality Constraints

Upper and lower bounds on the active power of slack bus (P_g), and reactive power of generators (Q_g) are written in mathematically as follows:

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

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

Upper and lower bounds of the bus voltage magnitudes (V_i) is written by:

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

Upper and lower bounds of the transformers tap ratios (T_i) is written by:

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

Upper and lower bounds of the compensators (Q_c) is written by:

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

Where N is the total number of buses, N_g is the total number of generators, N_T is the total number of Transformers, N_c is the total number of shunt reactive compensators.

III.AMERICAN BUFFALO ALGORITHM

American Buffalo (AB) algorithm pretends the vigilant sound and anxiety sound - behaviour of American buffalos in its scavenging endeavours. These vigilant and anxiety are the two elementary sounds of the american buffalos with which they are able to organize themselves to explore for food and guard themselves whenever they are attacked. The anxiety sound is used to rally the buffalos to travel on to explore the search space while the vigilant sound expresses the buffalos to stay on to exploit their environment since it is safe and has sufficient pastures. With these sounds, the buffalos are able to optimize their search for food source (Julius Beneoluchi Odili et al., 2015) [13]. The AB is a population-based algorithm in which individual buffalos work together to solve reactive power problem. Each buffalo within the AB algorithm epitomises an aggregate object containing a number of elements. The American Buffalo algorithm identifies the independent nature of the buffalos and integrates this into the algorithm. This is represented by Equation (10).

$$c_{k+1} = c_k + r_{g1}a_1(lo_{max} - d_k) + r_{g2}a_2(lf_{max} - d_k) \quad (10)$$

Where c_k and d_k represents the exploration and exploitation moves respectively of the k th buffalo ($k = 1, 2, \dots, N$); r_{g1} and r_{g2} are learning factors; a_1 and a_2 are arbitrary numbers between $[0, 1]$; lo_{max} is the

herd's best fitness and lf_{max} is the individual buffalo's best one.

In the above equation (10), there is an interface of the numerous buffalos with the prominent (best) buffalo at a specific iteration, a comparison with each buffalos best ever location in relative to the target solution as well as a memory of each animals immediate past location. Depending on the result of the equation (10), the animals move on to explore other locations as expressed in equation (11),

$$d_{k+1} = \lambda(c_k + d_k) \quad (11)$$

Where λ is a unit of time. The algorithm starts by initializing the population of animals through sensible distribution of arbitrary locations to each buffalo within the N -dimensional space. After this, the algorithm modernizes each buffalo's fitness and determines the lf_{max} (individual buffalo's location) and lo_{max} (the herd's best location) in specific iteration in relation to the optimal solution. If the existing fitness is superior to the individual's maximum fitness (lf_{max}), it protects the location vector for the particular buffalo. If the fitness is superior than the herd's overall extreme, it protects it as the herd's maximum (lo_{max}). Lastly it modernizes the buffalo's position and looks at the subsequent buffalo in the population. At this point, if our global best fitness meets our exit criteria, it ends the run and delivers the location vector as the solution to the given problem. Twofold key equations control the movement of buffalos within the search space and these are Equations (10) and (11). The equation (10) provides the decision to either stay on to exploit the environment further or to travel on to search other areas based on the collective intelligence of the herd after intermingling with each other in a communal decision-making process.

The equation (11) pushes the buffalos to travel on to search other areas based on the consequence of (10) after due consideration of the two competing forces (lo_{max}, lf_{max}). The λ parameter which outlines the discrete time interval over which the buffalo must move is usually set to 1.0. The application of these two Equations results in a new location for the buffalos. It should be observed that equation (10) aside from the memory part (c_k), have two other controlling features, namely, the global maximum (lo_{max}) and the individual maximum positions (lf_{max}): each defining the representative influence over the animal's location.

The algorithm subtracts the dimensional element d_k from the maximum vector and then multiplies this by an arbitrary number (a_1, a_2) usually between 0.0 and 0.6 a learning/acceleration parameter (r_{g1}, r_{g2}). Using the arbitrary numbers between 0.0 and 0.6 has been effective in obtaining fast convergence. It should be emphasized that the arbitrary numbers give an amount of arbitrariness in the path to help the animals move throughout the search space. It does this by arbitrarily giving more or less emphasis to the global (lo_{max}) or individual maximum solutions depending on the need for more exploration or exploitation respectively as the algorithm developments.

AB algorithm for solving reactive power problem.

- a. Objective function of the problem
- b. Initialization: arbitrarily place buffalos to nodes at the solution space
- c. Update the buffalo's fitness values using Equation (10)
- d. Update the location of buffalo using equation (11)
- e. Is $l_{o_{max}}$ updating if yes, go to next step or else go to b
- f. If the ending criterion is not met, then go back to algorithm step c
- g. Output finest solution.

IV.SIMULATION RESULTS

Legitimacy of proposed AB algorithm has been confirmed by testing it in IEEE 30-bus, 41 branch system and it has 6 generator-bus voltage magnitudes, 4 transformer-tap settings, and 2 bus shunt reactive compensators.

Bus 1 is taken as slack bus and 2, 5, 8, 11 and 13 are considered as PV generator buses and others are PQ load buses. Control variables limits are given in Table I. In Table II the power limits of generators buses are enumerated.

TABLE I
PRIME VARIABLE LIMITS (PU)

List of Variables	Minimum	Maximum	Type
Generator Bus	0.95	1.1	Continuous
Load Bus	0.95	1.05	Continuous
Transformer-Tap	0.90	1.1	Discrete
Shunt Reactive Compensator	-0.10	0.30	Discrete

TABLE II
GENERATORS POWER LIMITS

Bus	P_g	P_{gmin}	P_{gmax}	Q_{gmin}
1	96.00	49	200	-19
2	79.00	18	79	-19
5	49.00	14	49	-11
8	21.00	11	31	-14
11	21.00	11	28	-12
13	21.00	11	39	-14

Table III shows the proposed AB methodology efficiently kept the control variables within limits. Table IV list out the overall comparison of the results of optimal solution obtained by various methods. AB is an attempt to develop a user-friendly, effective, efficient, simple-to-application algorithm that will demonstrate exceptional capacity in the exploitation and exploration of the search.

TABLE III
AFTER OPTIMIZATION VALUES OF CONTROL VARIABLES

Control Variables	AB
V1	1.0231
V2	1.0179
V5	1.0186
V8	1.0541
V11	1.0699
V13	1.0387
T4,12	0.00
T6,9	0.01
T6,10	0.90
T28,27	0.91
Q10	0.10
Q24	0.10
Real power loss	4.2879
Voltage deviation	0.9081

TABLE IV COMPARISON OF RESULTS

Techniques	Real power loss (MW)
SGA(Wu et al., 1998) [14]	4.98
PSO(Zhao et al., 2005) [15]	4.9262
LP(Mahadevan et al., 2010) [16]	5.988
EP(Mahadevan et al., 2010) [16]	4.963
CGA(Mahadevan et al., 2010) [16]	4.980
AGA(Mahadevan et al., 2010) [16]	4.926
CLPSO(Mahadevan et al., 2010) [16]	4.7208
HSA (Khazali et al., 2011) [17]	4.7624
BB-BC (Sakthivel et al., 2013) [18]	4.690
Proposed AB	4.2879

V.CONCLUSION

In this paper, (AB) algorithm has been successfully applied to solve optimal reactive power dispatch problem. Proposed AB algorithm has been verified in the standard IEEE 30 bus system. Simulation results show the vigour of proposed AB algorithm in reducing the real power loss. Detailed comparison of results given in table 4 and our proposed approach outperforms all other reported standard algorithm in reduction of real power loss The control variables obtained after the optimization by (AB) methodology are well within the limits. So by keeping the voltage profile within the stipulated limits the real power loss has been reduced by our projected American Buffalo Algorithm.

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