Real Power Loss Reduction by Electric Field, Lepas Anatifera Mating and Dunlin Optimization Algorithms

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ABSTRACT

In this paper Electric Field Algorithm (EFA), Lepas Anatifera Mating Optimizer (LMO) algorithm and Dunlin Optimization Algorithm (DOA) are projected to solve the power loss lessening problem. Key objectives are Power loss reduction, Voltage stability enhancement and Voltage deviation minimization.Based on the coulomb law of electrostatic force proposed algorithm has been modeled. In the proposed Electric Field Algorithm (EFA) electrostatic attractive force has been considered and in that highly charged particle, (best particles) attract the particles which possess low charges sequentially there will be movement in the exploration space. Most excellent charge particle possess the fitness value "1" and remaining particles may be between "0" to "1".Then in this paper Lepas Anatifera Mating Optimizer (LMO) algorithm has been designed for factual power loss lessening. Modelling of the LMO algorithm is based on the Mating behaviour of Lepas Anatifera. Lepas Anatifera attaches to the objects in water and grow. Lepas Anatifera has long penises and it will be nine to ten times greater than its own body size. Lepas Anatifera's mating group members are within reachable place to the penis. There will be maturing challenge to attain the mate. Primarily the length of the penis will play a direct role in determining the mating and size of the group. Penis length determines the exploration and exploitation. Exploitation process occur when the selection and mating is done between Lepas Anatifera with the preset penis length. Otherwise sperm emit procedure will occur and its termed as exploration process.In Dunlin Optimization Algorithm (DOA) the notable stimulation in the modelling of DOA is Relocation and belligerent deeds of dunlin. Dunlin clusters which mobile from one spot to other place in the course of relocation and the innovative exploration agent location is to evade the bang between the adjacent Dunlin. In IEEE 30 bus test system proposed Electric Field Algorithm (EFA), Lepas Anatifera Mating Optimizer (LMO) algorithm and Dunlin Algorithm (DOA) has been appraised. Simulation study shows that the EFA, LMO and DOA abridged the loss competently.

1. INTRODUCTION

Fundamental objective of this paper is Factual power loss lessening. Starting from conventional methods [1-5] to evolutionary computation algorithms [6-17] has been is applied. This paper proposes Electric Field Algorithm (EFA), Lepas Anatifera Mating Optimizer (LMO) algorithm and Dunlin Optimization Algorithm (DOA) for loss diminution. Proposed EFA approach is based on the coulomb law of electrostatic force and generally there will be attractive or repulsive force between two charged particles [18, 19]. In the proposed EFA approach charged particles are considered as agents and it moves in the exploration space due to attractive or repulsive forces. Most excellent charge particle possess the fitness value "1" and remaining particles may be between "0" to "1".

In Lepas Anatifera Mating Optimizer (LMO) mating actions of Lepas Anatifera has been emulated to solve the problem. In nature Lepas Anatifera attach to the matter in water and grow up. Lepas Anatifera possesses elongated penises and it may be even nine to ten times larger than its own body size. Lepas Anatifera's mating group has the members which is accessible to the penis. There will be promising competition to attain the mate. Chiefly the length of the penis will play a pilot role in determining the mating and size of the group. Postulation considered is 1. Randomly selection process is done with reverence to the penis length of Lepas Anatifera. 2. Sperm contribution for reproduction 3. Self- mating is very uncommon in Lepas Anatifera and not considered 4. At some precise Iteration when the penis length is elevated than set values then

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sperm emit procedure will happen. When the selection and mating is done between Lepas Anatifera with the pre-set penis length then the procedure is in exploitation. Or else with reverence to crossing the set value of penis length of Lepas Anatifera – sperm emit procedure will happen and it symbolize the exploration procedure. In Dunlin Optimization Algorithm (DOA) primary incitement in the design of DOA is Relocation and belligerent actions of dunlin. Naturally Dunlin will consume bugs, maggots and it lives in bunching mode. The cluster of Dunlin which moves from one place to alternative in the course of relocation and the fresh exploration agent location is to elude the smash between the contiguous Dunlin. During movement the Dunlin will perform Helix activity and it has been mathematically modeled in the DOA approach. Proposed Electric Field Algorithm (EFA), Lepas Anatifera Mating Optimizer (LMO) algorithm and Dunlin Optimization Algorithm (DOA condensed the loss proficiently.

2. PROBLEM FORMULATION

$$Minimization\ \tilde{F}(\bar{u},\bar{v}) \quad (1)$$

subject to

$$E(\bar{u},\bar{v}) = 0 \quad (2)$$

$$I(\bar{u},\bar{v}) = 0 \quad (3)$$

$$u = \left[VG_1,..,VG_{Ng}; QC_1,..,QC_{Nc}; T_1,..,T_{N_T}\right] \quad (4)$$

$$v = \begin{bmatrix} PG_{slack}; VL_1,..,VL_{N_{Load}}; \\ QG_1,..,QG_{Ng}; SL_1,..,SL_{N_T} \end{bmatrix} \quad (5)$$

$$OF_1 = P_{Min} = Min\left[\sum_{m}^{NTL} G_m\left[V_i^2 + V_j^2 - 2 * V_i V_j cos\emptyset_{ij}\right]\right] \quad (6)$$

$$OF_2 = Min\left[\sum_{i=1}^{N_{LB}}\left|V_{Lk} - V_{Lk}^{desired}\right|^2 + \sum_{i=1}^{Ng}\left|Q_{GK} - Q_{KG}^{Lim}\right|^2\right] \quad (7)$$

$$OF_3 = Min\ L_{Max} \quad (8)$$

$$L_{Max} = Max\left[L_j\right]; j = 1; N_{LB} \quad (9)$$

and
$$\begin{cases} L_j = 1 - \sum_{i=1}^{NPV} F_{ji}\frac{V_i}{V_j} \\ F_{ji} = -[Y_1]^1[Y_2] \end{cases} \quad (10)$$

$$L_{Max} = Max\left[1 - [Y_1]^{-1}[Y_2] \times \frac{V_i}{V_j}\right] \quad (11)$$

Parity constraints

$$0 = PG_i - PD_i - V_i\sum_{j\in N_B} V_j\left[G_{ij}cos\left[\emptyset_i - \emptyset_j\right] + B_{ij}sin\left[\emptyset_i - \emptyset_j\right]\right] \quad (12)$$

$$0 = QG_i - QD_i - V_i\sum_{j\in N_B} V_j\left[G_{ij}sin\left[\emptyset_i - \emptyset_j\right] + B_{ij}cos\left[\emptyset_i - \emptyset_j\right]\right] \quad (13)$$

Disparity constraints

$$P_{gslack}^{min} \le P_{gslack} \le P_{gslack}^{max} \quad (14)$$

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g \quad (15)$$

$$VL_i^{min} \le VL_i \le VL_i^{max}, i \in NL \quad (16)$$

$$TT_i^{min} \le TT_i \le TT_i^{max}, i \in N_{TT} \quad (17)$$

$$Q_c^{mini} \le Q_c \le Q_C^{maxi}, i \in N_C \quad (18)$$

$$|SL_i| \le S_{L_i}^{max}, i \in N_{TL} \quad (19)$$

$$VG_i^{min} \le VG_i \le VG_i^{max}, i \in N_g \quad (20)$$

$$MOF = OF_1 + x_i OF_2 + yOF_3 = OF_1 + \left[\sum_{i=1}^{NL} x_v\left[VL_i - VL_i^{min}\right]^2 + \sum_{i=1}^{NG} x_g\left[QG_i - QG_i^{min}\right]^2\right] + x_f OF_3 \quad (21)$$

$$VL_i^{min} = \begin{cases} VL_i^{max}, VL_i > VL_i^{max} \\ VL_i^{min}, VL_i < VL_i^{min} \end{cases} \quad (22)$$

$$QG_i^{min} = \begin{cases} QG_i^{max}, QG_i > QG_i^{max} \\ QG_i^{min}, QG_i < QG_i^{min} \end{cases} \quad (23)$$

3. ELECTRIC FIELD ALGORITHM

In Electric Field Algorithm (EFA) normally there will be attractive or repulsive force between two charged particles. In the proposed algorithm charged particles are considered as agents and it moves in the exploration space due to attractive or repulsive forces. Then the fitness of the population and candidate solution are defined by the charges. In the proposed Electric Field Algorithm (EFA) electrostatic attractive force has been considered and in that highly charged particle i.e most excellent or best particles attract the particles which possess low charges sequentially there will be movement in the exploration space.

The electrostatic force between two charged particles by coulombs law is given by:

$$F_{ij} = k_e\frac{o_i o_j}{r^2} \quad (24)$$

Magnitude of the electrostatic force is symbolized by F_{ij}, k_e is the coulomb constant, charges of the objects are $o_i o_j$, r indicates the scalar distance of the charges between each other.

$o_i's$ Electric field is given by:

$$Electric\ field_i = \frac{F_{ij}}{o_i} \quad (25)$$

With respect to mass of acceleration

$$a_i = \frac{F_{ij}}{M} \quad (26)$$

Position of the particles in the exploration space is given by,

$$S_i = \left(s_i^1, s_i^2,.., s_i^d\right)\ i = 1,2,3,..,N \quad (27)$$

The particle which possesses best or most excellent fitness value's position at 't' (time) is given by:

$$PS_i^d(t+1) = \begin{cases} PS_i^d(t) \;\; if \;\; f(PS_i(t)) < f(S_i(t+1)) \\ S_i^d(t+1) \;\;\; if \; f(S_i(t+1)) \le \; f(PS_i(t)) \end{cases} \quad (28)$$

Particles most excellent fitness value is denoted by:

$$PS_{best} = S_{best} \quad (29)$$

Charge "j" apply the force on charge "i" at time "t" is defined by:

$$F_{ij}^d(t) = K(t)\frac{o_i(t)*o_j(t)\left(PS_j^d(t)-S_i^d(t)\right)}{r_{ij}(t)+\varepsilon} \quad (30)$$

$$r_{ij}(t) = \left\|S_i(t), S_j(t)\right\|_2 \quad (31)$$

Coulomb constant (k_e) is defined with respect to iterations by:

$$k_e(t) = k_o * exp\left(-\alpha \frac{iteration}{maximum\ iteration}\right) \quad (32)$$

All particles exerting force on particle "i" at time "t" is given by,

$$F_i^d(t) = \sum_{j=1, j\neq i}^{N} random\,() \cdot F_{ij}^d(t) \quad (33)$$

In the dimensional space, electric field possessed by the "i" particle is given by,

$$Electric\ field_i^d(t) = \frac{F_i^d(t)}{o_i(t)} \quad (34)$$

Acceleration of the "i" particle at time "t" is defined based on Newton second law of motion by,

$$a_i^d(t) = \frac{q_i(t) \cdot Electric\ field_i^d(t)}{M_i(t)} \quad (35)$$

Particles velocity and position is modernized by,

$$L_i^d(t+1) = random\,() * L_i^d(t) + a_i^d(t) \quad (36)$$

$$S_i^d(t+1) = S_i^d(t) + L_i^d(t+1) \quad (37)$$

Through the calculation of the fitness function the charge of the particles are found. Most excellent charge particle possess the fitness value "1" and remaining particles may be between "0" to "1".

$$o_i(t) = o_j(t)\ i, j = 1,2,..,N \quad (38)$$

$$o_i(t) = exp\left(\frac{f_{PS_i}(t) - w\,(t)}{b(t)-w(t)}\right) \quad (39)$$

$$o_i(t) = \frac{o_i(t)}{\sum_{i=1}^{N} o_i(t)} \quad (40)$$

$$b(t) = minimum\left(f_j(t)\right), j \in (1,2,3,..,N) \quad (41)$$

$$w(t) = maximum\left(f_j(t)\right), j \in (1,2,3,..,N) \quad (42)$$

a. Start
b. Initialization of population
c. Velocity value initialized arbitrarily
d. For the agent "S" compute the fitness value
e. Fix iteration (t) =0
f. Reproduction and modernizing
g. $while\ stop\ criteria\ is\ not\ satisfied\ do$
h. Compute,
   $k_e(t) for\ i = 1; N\ do$
i. $Fitness_i(t)\ is\ computed$
j. In all directions sum of force $F_i(t)$ is computed
k. Acceleration $(a_i(t))$is computed
l. Particles velocity and position is modernized
m. End for
n. Output the optimal solution
o. End

4. LEPAS ANATIFERA MATING OPTIMIZER ALGORITHM

Lepas Anatifera Mating Optimizer (LMO) algorithm proposed for lessening of power loss. Mating behaviour of Lepas Anatifera has been imitated to solve the problem. Naturally Lepas Anatifera attaches to the objects in water and grow. Lepas Anatifera possesses long penises and it may be even nine to ten times greater than its own body size. Lepas Anatifera's mating group possess the members within reachable to the penis. There will be budding contest to reach the mate. Mainly the length of the penis will play a lead role in determining the mating and size of the group. Candidate solution of the proposed Anatifera Mating Optimizer (LMO) algorithm is expressed as,

$$Y = \begin{bmatrix} y_1^1 & \cdots & y_1^N \\ \vdots & \ddots & \vdots \\ y_n^1 & \cdots & y_n^N \end{bmatrix} \quad (43)$$

Upper and lower bounds are defined by,

$$Upper\ bound = [Upper\ bound_1, \dots, Upper\ bound_i] \quad (44)$$

$$Lower\ bound = [Lower\ bound_1, \dots, lower\ bound_i] \quad (45)$$

Based on the length of the penis two Lepas Anatifera will be selected. Assumptions are 1. Arbitrarily selection procedure is done with respect to the penis length of Lepas Anatifera 2. Contribution of sperm will be there for reproduction 3. Self-mating is very rare in Lepas Anatifera and it not considered in the procedure 4. At some specific Iteration when the penis length is high than set then sperm emit procedure will occur. Based on the above four assumptions exploration and exploitation performed in the projected Anatifera Mating Optimizer (LMO) algorithm.

For example, when the penis length has been fixed to 9 nine times greater than the size of Lepas Anatifera then at a single iteration a single Lepas Anatifera (number 2) can mate with of number 9 Lepas Anatifera. When the over limit occurs with respect to mate and size of the penis then sperm emit procedure will be employed.

The selection procedure of the mating between the parents to produce off-springs is defined as:

$$\text{Lepas Anatifera\_A} = \text{Random perm (number of population)} \quad (46)$$

$$\text{Lepas Anatifera\_B} = \text{Random perm (number of population)} \quad (47)$$

Then the off-springs produced by the parents Lepas Anatifera _ A and Lepas Anatifera _ B with normal distribution $G \in [1,0]$ and $H = (1 - G)$ is defined as,

$$y_i^{N,new} = G y^N_{\text{Lepas Anatifera(Father)}} + H y^N_{\text{Lepas Anatifera(Mother)}} \quad (48)$$

In the above equation G and H indicates the proportion of the personality which has been entrenched in the off springs. The main factor that determines the exploration and exploitation is the penis length. When the selection and mating is done between Lepas Anatifera with the fixed penis length then the process is under exploitation. Otherwise with respect to crossing the penis length of Lepas Anatifera then sperm emit procedure will occur and it's termed as exploration process.

Sperm emit procedure mathematically defined as,

$$y_i^{N,new} = random\ (\,) + y^N_{\text{Lepas Anatifera(Mother)}} \quad (49)$$

The new offspring is engendered from mother Lepas Anatifera and the mother receives the sperm from water which has been emitted by other Lepas Anatifera.

a. Start
b. Population engendered
c. Lepas Anatifera aptness value is computed
d. Classify Lepas Anatifera
e. $(\,Q = Best\ \ solution)$
f. $While\ (I < Maximum\ number\ of\ iterations)$
g. Set the value of the penis length
h. Selection procedure applied

$$\text{Lepas Anatifera\_A} = \text{Random perm (number of population)}$$

$$\text{Lepas Anatifera\_B} = \text{Random perm (number of population)}$$

i. When the selection of parents (Father and mother) of Lepas Anatifera is done based on the penis length, then for each variable- offspring generation done by,

$$y_i^{N,new} = G y^N_{\text{Lepas Anatifera(Father)}} + H y^N_{\text{Lepas Anatifera(Mother)}}$$

j. End for
k. Otherwise When the selection of parents (Father and mother) of Lepas Anatifera is greater than penis length then for each variable- offspring generation done by

$$y_i^{N,new} = random\ (\,) + y^N_{\text{Lepas Anatifera(Mother)}}$$

l. End for
m. End if
n. Bring back the Lepas Anatifera which crossed the boundary limit
o. Fitness value of each Lepas Anatifera is computed
p. Classify Lepas Anatifera
q. Update "Q"
r. $I = I + 1$
s. End while
t. Return 'Q"

5. DUNLIN OPTIMIZATION ALGORITHM

In Dunlin Optimization Algorithm (DOA) the foremost incitement in the modelling of DOA is Relocation (Travelling) and belligerent activities of dunlin. Dunlin will consume bugs; maggots and it lives in clustering mode. The cluster of Dunlin which travel from one spot to alternative in the course of relocation and the new-fangled exploration agent location is to avoid the crash between their adjacent Dunlin is described mathematically as follows:

$$Location\ of\ the\ explore\ agent\ (D_{EA}) = Progression_D + Current\ position\ of\ Explore\ agent\ (Cp_{EA}) \cdot (Current\ iteration\ (i)) \quad (50)$$

$$Progression_D = progression_{control\ frequency(cf)} - \left((i) * progression_{(cf)} / max_{iteration}\right)\ ; i = 1,2,3,4,..,max_{iteration} \quad (51)$$

Exploration agents move towards the preeminent agent and it expressed mathematically as follows:

$$Location\ of\ \ explore\ agent\ (LSF) = Capricious\ Variable\ (CV) * (CP_{Best}(i) - (Cp_{EA}) \cdot (Current\ iteration\ (i))\,) \quad (52)$$

$$Capricious\ Variable\ (CV) = 0.50\ * Random \quad (53)$$

With respect to most excellent location Dunlin will update its position:

$$Crevice\ \left(S_{Cp \cdot Mf}\right) = D_{EA} + LSF \quad (54)$$

During movement the Dunlin will perform Helix activity and the belligerent activities of Dunlin is mathematically defined as:

$$G' = Radius\ (R) * \sin(n) \quad (55)$$

$$H' = Radius\ (R) * \cos(n) \quad (56)$$

$$I' = Radius\ (R) * (n) \quad (57)$$

$$Radius\ (R) = W * Base^{LX}\ ; W and\ X\ are\ constant\ to\ define\ the\ path\ (helix) \quad (58)$$

Updating the Position of the Explore agents is performed as follows:

$$Current\ position\ of\ Explore\ agent\ (Cp_{EA}) = \left(Crevice\ \left(S_{Cp \cdot Mf}\right) * (G' + H' + I') * Cp_{Best}\right) \quad (59)$$

a. Start
b. Define the Parameters
c. $Z_G = Explore\ agents\ Top\ most\ best\ solution$
d. $Z_H = Explore\ agents\ Second\ \ best\ solution$
e. $Z_I = Explore\ agents\ Third\ best\ solution$
f. $T = 0$
g. $while\ (t < max.No\ of\ Iter.)$
h. Each explore agent fitness value will be computed
i. Each location (position) of the explore agent will be updated
j. Compute the fitness value of explore agent
k. $Update\ the\ values;\ Z_G\ , Z_H, Z_I$
l. $T = t + 1$
m. If most excellent solution obtained when compare to the previous solution then stop
n. End while
o. End

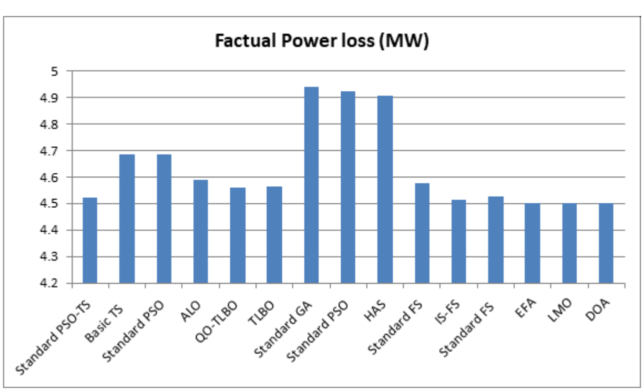

Fig 1. Appraisal of actual power loss.

Table 2. Evaluation of power deviation

Procedure	Power deviancy in PU
PSOTVIW-H [15]	0.1038
PSOTVAC-H [15]	0.2064
PSOTVAC-H [15]	0.1354
PSOCF-H [15]	0.1287
PGPSO-H [15]	0.1202
SWTPSO-H [15]	0.1614
PGSWTPSO-H [15]	0.1539
MPGPSO-H [15]	0.0892
QOTLBO-H [12]	0.0856
TLBO-B [12]	0.0913
FS-B [14]	0.1220
ISFS-H [14]	0.0890
FS-S [16]	0.0877
EFA	0.0833
LMO	0.0867
DOA	0.0860

Table 3. Assessment of power reliability

Method	Power reliability (PU)
PSOTVIW-H [15]	0.1258
PSOTVAC-H [15]	0.1499
PSOTVAC-H [15]	0.1271
PSOCF-H [15]	0.1261
PGPSO-H [15]	0.1264
WTPSO-H [15]	0.1488
PGSWTPSO-H [15]	0.1394
MPGPSO-H [15]	0.1241
QOTLBO-H [12]	0.1191
TLBO-B [12]	0.1180
ALO-B [11]	0.1161
ABC-B [11]	0.1161
GWO-B [11]	0.1242
BA-S [11]	0.1252
FS-B [14]	0.1252
ISFS-H [14]	0.1245
FS-S [16]	0.1007
EFA	0.1003
LMO	0.1005
DOA	0.1006

6. SIMULATION RESULTS

With and without considering L- index (voltage constancy), Electric Field Algorithm (EFA), Lepas Anatifera Mating Optimizer (LMO) algorithm and Dunlin Optimization Algorithm (DOA) are substantiated in IEEE 30 bus system [20]. Tables 1, 2, 3 and 4 shows the loss appraisal, voltage deviancy evaluation and L-index appraisal. Figures – 1 and 2 gives graphical review.

Table 4. Evaluation of true power

Method	Loss in MW	Fraction of attenuation in Loss
Base [24]	17.5500	0.0000
PSO-S [24]	16.0700	8.40000
PSO-B [23]	16.2500	7.4000
EP-S [21]	16.3800	6.60000
GA-S [22]	16.0900	8.30000
PSO-S [25]	17.5246	0.14472
DEPSO-H [25]	17.52	0.17094
JAYA-B [25]	17.536	0.07977
EFA	14.03	20.056
LMO	14.17	19.25
DOA	14.14	19.43

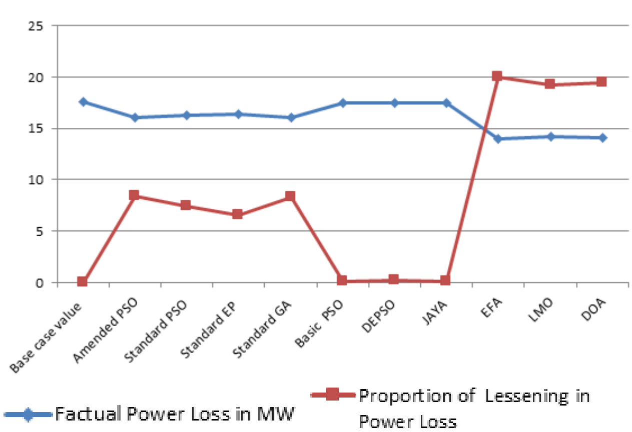

Fig 2. Appraisal of Factual Power Loss.

7. CONCLUSION

In this paper Electric Field Algorithm (EFA), Lepas Anatifera Mating Optimizer (LMO) algorithm and Dunlin Optimization Algorithm (DOA) reduced the power loss effectually.In EFA approach charged particles are considered as agents and it moves in the exploration space due to attractive or repulsive forces. Then the fitness of the population and candidate solution are defined by the charges. Through the calculation of the fitness function the charge of the particles are found. Most excellent charge particle possess the fitness value "1" and remaining particles may be between "0" to "1".In LMO algorithm "G" and "H" indicates the proportion of the personality which has been entrenched in the off springs. The main factor that determines the exploration and exploitation is the penis length. Lepas Anatifera's mating group has the members which is accessible to the penis. There will be promising competition to attain the mate. Chiefly the length of the penis will play a pilot role in determining the mating and size of the group. When the selection and mating is done between Lepas Anatifera with the fixed penis length then the process is under exploitation. Otherwise with respect to crossing the penis length of Lepas Anatifera then sperm emit procedure will happen and it's termed as exploration process. Dunlin Optimization Algorithm (DOA) foremost incitement in the modelling is Relocation and belligerent activities of dunlin. Exploration agents move towards the preeminent agent and during movement the Dunlin will perform Helix activity. Proposed algorithms validated in standard system. Simulation study shows that the projected EFA, LMO and DOA reduced the true power loss proficiently. Power loss (MW) obtained by EFA is 4.5003, LMO - 4.5014 and DOA -4.5011 with considering Voltage stability. Then power loss (MW) obtained by EFA is 14.03, LMO -14.17 and DOA-14.14 without considering Voltage stability. Predominantly the percentage of actual power loss reduction has been improved.

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