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ENHANCED ALGORITHM FOR REDUCTION OF ACTIVE POWER LOSS

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Abstract

In this paper, Enhanced Aggressive Weed Optimization (EWO) algorithm is applied to solve the optimal reactive power Problem. Aggressive Weed Optimization is a stochastic search algorithm that imitate natural deeds of weeds in colonize and detection of appropriate place for growth and reproduction. Enhanced Aggressive Weed Optimization (EWO) algorithm is based on hybridization of genetic algorithm with weed optimization algorithm which refers combination of crossover and mutation of genetic algorithm, and by the use of the cross factor new species are arisen. Proposed Enhanced Aggressive Weed Optimization (EWO) algorithm has been evaluated in standard IEEE 118 & practical 191 bus test systems. Simulation results show that our projected approach outperforms all the entitled reported algorithms in minimization of real power loss and voltage profiles are within the specified limits.

Keywords: Aggressive Weed Optimization; Genetic Algorithm; Optimal Reactive Power; Power System.

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1. Introduction

To improve the economy and safety of power system optimal reactive power problem has been acknowledged with huge attention. Many conventional methods such as gradient based, interior point, linear programming & quadratic programming [1-6] have been to the reactive power problem. But many drawbacks have been found in the conventional methods and mainly handling the inequality constraints found to be very complex. Last two decades many evolutionary algorithms [7-9] have been applied to solve the reactive power problem. To improve the trade of between exploration & exploitation in order to reach the global solution, a new hybridized algorithm called Enhanced Aggressive Weed Optimization (EWO) algorithm proposed to solve the reactive power flow problem. It imitate the natural deeds of weeds in colonize and found a perfect place for growth and reproduction. Enhanced Aggressive Weed Optimization (EWO) algorithm is based on hybridization of basic characteristics of genetic algorithm with weed

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optimization algorithm that is combination of crossover and mutation of genetic algorithm, into cross factor which leads to arising of new species. The way of reproduction, spatial dispersion, and aggressive elimination are few exclusive properties of the proposed Enhanced Aggressive Weed Optimization (EWO) algorithm. Proposed Enhanced Aggressive Weed Optimization (EWO) algorithm has been evaluated in standard IEEE 118 & practical 191 bus test systems. Simulation results show that our projected approach outperforms all the entitled reported algorithms in minimization of real power loss and voltage profiles are within the specified limits.

2. Problem Formulation

2.1. Active Power Loss

The objective of the reactive power dispatch is to minimize the active power loss in the transmission network, which can be described as follows:

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

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.

2.2. Voltage Profile Improvement

For minimizing the voltage deviation in PQ buses, the objective function becomes:

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

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

Voltage deviation given by:

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

Where Npq- number of load buses

2.3. Equality Constraint

The equality constraint of the problem is represented by the power balance equation, where the total power generation must cover the total power demand and the power losses:

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

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

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2.4. Inequality Constraints

The inequality constraints in the power system as well as the limits created to ensure system security. Upper and lower bounds on the active power of slack bus (Pg), and reactive power of generators (Q_g) are written in mathematically as follows:

$$P_{gslack}^{min} \leq P_{gslack} \leq P_{gslack}^{max} \tag{5}$$

$$Q_{gi}^{min} \leq Q_{gi} \leq Q_{gi}^{max}, i \in N_g \tag{6}$$

Upper and lower bounds on the bus voltage magnitudes (V_i):

$$V_i^{min} \leq V_i \leq V_i^{max}, i \in N \tag{7}$$

Upper and lower bounds on the transformers tap ratios (T_i):

$$T_i^{min} \leq T_i \leq T_i^{max}, i \in N_T \tag{8}$$

Upper and lower bounds on the compensators reactive powers (Q_c):

$$Q_c^{min} \leq Q_c \leq Q_C^{max}, i \in N_C \tag{9}$$

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

3. Enhanced Aggressive Weed Optimization (EWO) Algorithm

Colonizing behaviour [10-14] is the basic character found in the weeds and it has been imitated to design weed algorithm. Weed Optimization algorithm is summarized as follows,

Initialize
At the same element position a finite number of weeds which has a uniform spacing of $\lambda/2$ between neighboring elements are initialized in conventional array.

Reproduction Satge
As per the colony's lowest and highest fitness, each member of the population is allowed to produce seeds . Number of seeds produced by a weed augments with worst fitness to the maximum number of seeds for a plant with most excellent fitness.

Spatial Allotment
Generated seeds are being arbitrarily distributed & Through this step the seeds will be spawn around the parent weed, this deed leads to local search around each plant. Over the iterations the standard deviation (sde) of the arbitrary function is made to decrease.If sde _ max and sde _ min be the maximum and minimum standard deviation & "pow" be a real number then the standard deviation (sde) for a particular iteration is given as in equation (10) as below,

$$\mathrm{sde}_{ITER} = \left(\frac{iter_{max}-iter}{iter_{max}}\right) \mathrm{pow}\ (\mathrm{sde}_{\max} - \mathrm{sde}_{\min}) + \mathrm{sde}_{\min} \quad (10)$$

Reasonable Elimination

Until the number of plants in the colony reaches a maximum value pop_{max} the plants in a colony will reproduce fast and all will be included in the colony. Fitter plants have been reproduced more than the adverse plants. Then fittest plants are the reproduced ones & taken in the colony. Until the maximum number of iterations has been reached, Steps 1 to 4 are repeated. This method is known as reasonable exclusion.

Alteration: We have tailored the equation (10) as:

$$\mathrm{sde}_{ITER} = \left(\frac{iter_{max}-iter}{iter_{max}}\right) \mathrm{pow}\ |\cos(iter)|(sde_{max} - sde_{min}) + sde_{min} \quad (11)$$

For exploring the enhanced solutions rapidly |cos(iter)| append a variation in sde and when the sde is comparatively big, the new-fangled solutions which stretch out of the exploration space has been prevented. In order to achieve smaller values of sde standard deviation are varied within an envelope much before the conclusion of the run.

Enhanced Aggressive Weed Optimization (EWO) algorithm is based on hybridization of basic characteristics of genetic algorithm with weed optimization algorithm that is combination of crossover and mutation of genetic algorithm, into cross factor which leads to arising of new species. The way of reproduction, spatial dispersion, and aggressive elimination are few exclusive properties of the proposed Enhanced Aggressive Weed Optimization (EWO) algorithm. In cross factor method, choose half particles whose fitness value are superior will directly go into the subsequent generation, & good fitness one will be in first half the particle's position and speed vector swap's lower half of the particles, and to keep the latter vector extremely unchanged. Half after particles has to cross factor random combination pairing in cross mechanism and crossover operation will produce offspring as in genetic algorithm, and it will generate offspring. Compare with the parent generation, half particle which fitness value is superior will go to the subsequent generation. The cross procedure increases the diversity of particles which will augment convergence speed.

4. Enhanced Aggressive Weed Optimization (EWO) Algorithm for Solving Reactive Power Problem

1) From the set of feasible solutions produce arbitrary plants of Number of individuals
2) i=: 1
3) do

- maximum and minimum fitness in the colony has been computed
- ωϵW for each individual

1) Corresponding to the fitness, compute the number of seeds for ω
2) Around the parent plant (ω) arbitrarily select the seeds from the feasible solutions in a neighbourhood with normal distribution.
3) To the solution set W, generated seeds ahs to be added.

4) Select corresponding number of generated seeds to do hybrid operation, for the parent plant whose seeds number is limited to zero,

Seed (x) = T x Parent (x) + (1.000 - t) X Parent (x) (12)

Where “T” is an arbitrary value between 0 and 1.

Again generated seeds have to be added to the solution set,

- If whole number exceeds $p_{max,}$ then

i. population N has to be sorted in descending order of their fitness
ii. Smaller fitness weeds population has to be Truncated until N = P_{ma}

- i = i + 1

Reiterate step 3 until the maximum number of iterations is reached.

5. Simulation Results

At first Enhanced Aggressive Weed Optimization (EWO) algorithm has been tested in standard IEEE 118-bus test system [15]. 54 generator buses, 64 load buses, 186 branches and 9 of them are with the tap setting transformers are in standard IEEE 118-bus test system . The limits of voltage on generator buses are 0.95 -1.1 per-unit., and on load buses are 0.95 -1.05 per-unit. With the changes step of 0.025 the limit of transformer rate is 0.9 -1.1. with the change in step of 0.01 the limitations of reactive power source are listed in Table 1.

Table 1: Limitation of reactive power sources

BUS	5	34	37	44	45	46	48
QCMAX	0	14	0	10	10	10	15
QCMIN	-40	0	-25	0	0	0	0
BUS	74	79	82	83	105	107	110
QCMAX	12	20	20	10	20	6	6
QCMIN	0	0	0	0	0	0	0

In Table 2 statistical comparison results have been given and proposed Enhanced Aggressive Weed Optimization (EWO) algorithm performs well in reducing the real power loss.

Table 2: Comparison results

Active power loss (p.u)	**BBO [16]**	**ILSBBO/ strategy1 [16]**	**ILSBBO/ strategy1 [16]**	**Proposed EWO**
Min	128.77	126.98	124.78	116.520
Max	132.64	137.34	132.39	120.980
Average	130.21	130.37	129.22	118.620

Then the Enhanced Aggressive Weed Optimization (EWO) algorithm has been tested in practical 191 test system and the following results have been obtained. In Practical 191 test bus system – Number of Generators = 20, Number of lines = 200, Number of buses = 191 Number of

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transmission lines = 55. Optimal control values of practical 191 test system obtained by EWO method has been listed in Table 3. Value of the real power loss by obtained by Enhanced Aggressive Weed Optimization (EWO) algorithm has been shown in Table 4.

Table 3: Optimal Control values of Practical 191 utility (Indian) system by EWO method

VG1	1.1000		VG 11	0.9000
VG 2	0.7600		VG 12	1.0000
VG 3	1.0100		VG 13	1.0000
VG 4	1.0100		VG 14	0.9000
VG 5	1.1000		VG 15	1.0000
VG 6	1.1000		VG 16	1.0000
VG 7	1.1000		VG 17	0.9000
VG 8	1.0100		VG 18	1.0000
VG 9	1.1000		VG 19	1.1000
VG 10	1.0100		VG 20	1.1000

T1	1.0000		T21	0.9000		T41	0.9000
T2	1.0000		T22	0.9000		T42	0.9000
T3	1.0000		T23	0.9000		T43	0.9100
T4	1.1000		T24	0.9000		T44	0.9100
T5	1.0000		T25	0.9000		T45	0.9100
T6	1.0000		T26	1.0000		T46	0.9000
T7	1.0000		T27	0.9000		T47	0.9100
T8	1.0100		T28	0.9000		T48	1.0000
T9	1.0000		T29	1.0100		T49	0.9000
T10	1.0000		T30	0.9000		T50	0.9000
T11	0.9000		T31	0.9000		T51	0.9000
T12	1.0000		T32	0.9000		T52	0.9000
T13	1.0100		T33	1.0100		T53	1.0000
T14	1.0100		T34	0.9000		T54	0.9000
T15	1.0100		T35	0.9000		T55	0.9000

Table 4: Optimum real power loss values obtained for practical 191 utility (Indian) system by EWO method

Real power Loss (MW)	**EWO**
Min	143.002
Max	146.078
Average	144.012

6. Conclusion

In this paper, Enhanced Aggressive Weed Optimization (EWO) algorithm successfully solved optimal reactive power problem. Enhanced Aggressive Weed Optimization (EWO) algorithm is based on hybridization of basic characteristics of genetic algorithm with Aggressive weed optimization algorithm that is combination of crossover and mutation of genetic algorithm, into

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cross factor which leads to arising of new species. Proposed Enhanced Aggressive Weed Optimization (EWO) algorithm has been evaluated in standard IEEE 118 & practical 191 bus test systems. Simulation results show that our projected approach outperforms all the entitled reported algorithms in minimization of real power loss and voltage profiles are within the specified limits.

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