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Air cloud algorithm for diminution of active power loss

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ABSTRACT

In this work, air cloud (AC) algorithm is used to solve the optimal reactive power problem. Clouds shape in numerous ways. Convective clouds are created when moist air is warmed and expand into floating. Air raises haulage water vapour and within it expands and gets cooled as it goes. As the temperature and pressure of the air diminish, its saturation point – the equilibrium level of evaporation and condensation – is reduced. Every x is one cloud droplet, and qualitative characteristic of one cloud is explained by the three digital character (Ex, En, He), droplets number n, where Ex (Expected value), En (Entropy) and He (Hyper entropy) of one cloud determine centre position of cloud, cover range of cloud and thickness of cloud equally. Projected AC algorithm has been tested in standard IEEE 14, 57, 300 bus systems and simulations results show the better performance of the proposed algorithm in reducing the real power loss.

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1. INTRODUCTION

Reactive power optimization problem plays main role in secure & economic operation of the power system. Several conventional methods [1-8] used already for solving the problem. Various drawbacks have been found in the conventional methods and mainly difficulty in handling the inequality constraints. Last two decades many evolutionary algorithms [9-20] has been applied tom solve the problem. In this work air cloud (AC) algorithm has been applied to solve the optimal reactive power problem. Dynamics of cloud development, expansion, motion and dissipation are versatile. In the progress of a cloud simulation, it is significant to realize dynamics so that high-quality estimation can be selected which allow competent implementation without sacrifice realism. AC algorithm is stimulated from the actions of cloud such as formation performance, varying performance and spread out actions of cloud. The whole explore space is alienated into several dislodge regions according to the particular rule, and each region possess with air pressure value and humidity value. Projected AC algorithm has been tested in standard IEEE 14, 57, 300 bus systems and simulations results show the better performance of the proposed algorithm in reducing the real power loss.

2. PROBLEM FORMULATION

Objective of the problem is to reduce the true power loss:

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

Voltage deviation given as follows:

$$F = P_L + \omega_v \times \text{Voltage Deviation} \tag{2}$$

Voltage deviation given by:

$$\text{Voltage Deviation} = \sum_{i=1}^{Npq} |V_i - 1| \tag{3}$$

Constraint (Equality)

$$P_G = P_D + P_L \tag{4}$$

Constraints (Inequality)

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

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

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

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

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

3. AIR CLOUD ALGORITHM

AC algorithm is stimulated from the actions of cloud such as formation performance, varying performance and spread out actions of cloud. The whole explore space is alienated into several dislodge regions according to the particular rule, and each region possess with air pressure value and humidity value. Clouds are able to be engendered in regions with dampness value are superior to precise threshold. Underneath the venture of wind, clouds shift from regions with superior air pressure value towards lower air pressure value regions. In the movement procedure, the droplets of one cloud would expand or get hold of joint action according to the air pressure difference.

Presume that U is the space; the region is defined as subspace after the separation of U according to various systems and dimension of U is alienated into M minute hiatus

$$I_i = \frac{(u_i - l_i)}{M}, i = 1,2,\dots,D \tag{10}$$

Entire search space split into MD regions, which meet up the subsequent property:

$$\begin{cases} \bigcup_{i=1}^{M^D} U_i = U \\ U_i \cap U_j = \emptyset, \forall i,j \in \{1,2,\dots,M^D\}, I \ne j \end{cases} \tag{11}$$

In U Cloud C is defined as a qualitative observation, and x is the stochastic implementation of C, $x \in U$. Every x is one cloud droplet, and qualitative characteristic of one cloud is explained by the three digital character (Ex, En, He) , droplets number n, where Ex (Expected value), En (Entropy) and He (Hyper-entropy) of one cloud determine centre position of cloud, cover range of cloud and thickness of cloud equally.

Assume m clouds in iteration t, then:

$$C^t = \{C_1^t, C_2^t, \dots, C_j^t, \dots, C_m^t\} \tag{12}$$

Clouds droplets numbers,

$$n^t = \{n_1^t, n_2^t, \ldots, n_j^t, \ldots, n_m^t\} \quad (13)$$

All clouds droplets numbers,

$$\begin{cases} n_j > dN, \ \ \forall j = 1,2,\ldots,m \\ \sum_{j=1}^{m} n_j \leq N \end{cases} \quad (14)$$

$$C(x) \sim N(C \cdot Ex, En'^2) \quad (15)$$

Dampness value of the region is,

$$X_i^* = \underset{x \in U_i}{\arg\max} f(x), \ H_i f(X_i^*) \quad (16)$$

Air pressure value is:

$$P_i = CNT(x \in U_i), i = 1,2,\ldots,M^D \quad (17)$$

$$Ht = H_{min} + \lambda^*(H_{max} - H_{min}) \quad (18)$$

Creation of cloud regions as

$$R = \{i | H_i > Ht, i = 1,2,\ldots,M^D\}$$

Preliminary entropy value EnMo found by,

$$EnMo = \frac{I/M}{A} \quad (19)$$

$$EnM^t = EnM^0 \times \xi \quad (20)$$

Total number of droplets recently generated in existing iteration is found by

$$nNew = N - \sum_{j=1}^{m} n_j^t \quad (21)$$

Assume $R = \{i|H_i > Ht, i = 1,2,\ldots,M^D\}$ has k elements, the clouds recently engendered are, $C_{m+1}^t . C_{m+2}^t, \ldots, C_{m+j}^t, \ldots, C_{m+k}^t$. Then the droplets number of cloud newly generated has a relative relation with the humidity of regions [21, 22] in R, is given by,

$$n_{m+j}^t = \frac{H_{R(j)}}{\sum_{j=1}^{k} H_{R(j)}} \times nNew \quad (22)$$

Recently generated of clouds features are described as,

$$C_{m+j}^t \cdot Ex = X_{s(j)}^*, C_{m+j}^t \cdot En = EnM^t, C_{m+j}^t \cdot He = He, 0 < j \leq k. \quad (23)$$

Presume the region where the cloud $c_j^t (j = 1,2,\ldots,m)$ positioned is designated as US, and then arbitrarily pick one region of air pressure value is inferior than U_s's as the objective region UT, then differentiation of pressure between US and UT is found by$\Delta P = P_S - P_T$. Modernized equation of cloud's location is found by:

$$C_j^{t+1} \cdot Ex = C_j^t \cdot Ex + \vec{V}_j^{t+1}, 0 < j \le m \quad (24)$$

Altering velocity of cloud is found by,

$$\vec{V}_j^{t+1} = \vec{e} \times 6 \times C_j^t \cdot En \quad (25)$$

$$\vec{e} = \frac{(1-\beta) \times \vec{V}_j^t + \beta \times (X_T^* - C_j^t \cdot Ex)}{\|(1-\beta) \times \vec{V}_j^t + \beta \times (X_T^* - C_j^t \cdot Ex)\|} \quad (26)$$

$$\beta = \frac{\Delta p}{P_{max} - p_{min}} \quad (27)$$

B indicates the persuading degree of air pressure with the fitness value of X_T^* specify the humidity value within the region UT . Owing to the vanishing or have a collision between clouds in the shift process power of cloud get diminish, so weaken rate γ, is added as$\gamma \times 100\%$ after each iteration. Modernized droplets number is found by:

$$n_j^{t+1} = n_j^t \times (1-\gamma)\ 0 < j \le m \quad (29)$$

When droplets are a lesser amount to dN subsequent step, it is considered as deteriorated. γ is primarily used to verify the speed of clouds, which movedand the value considered as$\gamma = 0.190$. Assume the region where the cloud $c_j^t (j = 1,2,\ldots,m)$ situated is US, and when UT $\neq$ US, the expanded fleetness of cloud is articulated as:

$$C_j^{t+1} \cdot En = C_j^t \cdot En \times (1+\alpha) \quad (29)$$

α is expand factorand computed by,

$$\alpha = \frac{\Delta P}{P_{max}} \quad (30)$$

Pmax is the greatest air pressure difference in the search space; $\Delta P = P_S - P_T$ is the pressure difference between US and UT. When UT = US, the cloudC_j^t will expand according to the maximum pressure with difference between US and peripheral regions, the dampness values ,air pressure values of all regions is updated every time subsequent to the making process of cloud, the cloud's alter procedure and expand progression.

a. Initialization of the procedure
b. creation of Clouds
c. modernize Humidity Value, Air Pressure value of area
d. alter behaviour of Cloud is computed
e. expand Behaviour of Cloud is computed
f. modernize Humidity Value, Air Pressure Value of area
g. if End of Loop, thenstop or elsemove to Step c

4. SIMULATION RESULTS

At first in standard IEEE 14 bus system the validity of the proposed algorithm has been tested and comparison results are presented in Table 1 (using [23]). Real power loss has been considerably reduced and vital parameters are within the limits. Then the performance of the projected algorithm has been validated by tested in standard IEEE 57 bus system [24]. Total active and reactive power demands in the system are 1248.23 MW and 334.16 MVAR. Generator data the system is given in Table 2. The optimum loss comparison (of [25–28]) is presented in Table 3. Then the performance of the proposed algorithm has been tested in standard IEEE 300 bus system [24]. Table 4 shows the comparison [28, 29] of real power loss obtained after optimization.

Table 1. Comparison of real power loss

Control variables	ABCO [23]	IABCO [23]	AC
V1	1.06	1.05	1.04
V2	1.03	1.05	1.03
V3	0.98	1.03	1.04
V6	1.05	1.05	1.01
V8	1.00	1.04	0.90
Q9	0.139	0.132	0.100
T56	0.979	0.960	0.900
T47	0.950	0.950	0.900
T49	1.014	1.007	1.000
Ploss (MW)	5.92892	5.50031	4.10028

Table 2. Generator data

Generator No	Pgi minimum	Pgi maximum	Qgi minimum	Qgi maximum
1	25.00	50.00	0.00	0.00
2	15.00	90.00	-17.00	50.00
3	10.00	500.00	-10.00	60.00
4	10.00	50.00	-8.00	25.00
5	12.00	50.00	-140.00	200.00
6	10.00	360.00	-3.00	9.00
7	50.00	550.00	-50.00	155.00

Table 3. Comparison of losses

Parameter	CLPSO[26]	DE[25]	GSA[25]	OGSA[27]	SOA[26]	QODE[25]	CSA[28]	AC
PLOSS (MW)	24.5152	16.7857	23.4611	23.43	24.2654	15.8473	15.5149	12.1052

Table 4. Comparison of real power loss

Parameter	EGA [29]	EEA [29]	CSA [28]	AC
PLOSS (MW)	646.2998	650.6027	635.8942	622.0024

5. CONCLUSION

In this work, AC algorithm successfully solved the optimal reactive power problem. Actions of cloud such as formation performance, varying performance and spread out actions of cloud are modeled. In the movement procedure, the droplets of one cloud would expand or get hold of joint action according to the air pressure difference. Projected AC algorithm has been tested in standard IEEE 14, 57, 300 bus systems and simulations results show the better performance of the proposed algorithm in reducing the real power loss.

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