REDUCTION OF REAL POWER LOSS BY HYBRIDIZATION OF CHAOS OPTIMIZATION ALGORITHM WITH OUTLOOK ALGORITHM

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ABSTRACT

This paper presents Hybridization of chaos optimization algorithm with outlook algorithm (HCO),to solve optimal reactive power dispatch problem. The algorithm is organized in twofold phases. The first phase uses parallel chaos optimization grounded on tent map for global exploration, while outlook algorithm is engaged in the second phase for local exploration.The projectedHCO has been tested in standard IEEE 30 bus test system and simulation results show clearly the improved performance of the proposed algorithm in decreasing the real power loss.

Keywords: parallel chaos optimization, outlook algorithm, global optimization, tent map, optimal reactive power, Transmission loss.

I. INTRODUCTION

Reactive power optimization places an important role in optimal operation of power systems. Various numerical methods like the gradient method [1,2], Newton method [3] and linear programming [4,5,6,7] have been implemented to solve the optimal reactive power dispatch problem. Both the gradient and Newton methods have the intricacy in managing inequality constraints. The problem of voltage stability and collapse play a key role in power system planning and operation [8] Evolutionary algorithms such as genetic algorithm have been already projected to solve the reactive power flow problem [9,10,11]. Evolutionary algorithm is a heuristic methodology used for minimization problems by utilizing nonlinear and non-differentiable continuous space functions. In [12], Hybrid differential evolution algorithm is projected to increase the voltage stability index. In [13] Biogeography Based algorithm is projected to solve the reactive power dispatch problem. In [14], a fuzzy based method is used to solve the optimal reactive power scheduling method. In [15], an improved evolutionary programming is used to elucidate the optimal reactive power dispatch problem. In [16], the optimal reactive power flow problem is solved by integrating a genetic algorithm with a nonlinear interior point method. In [17], a pattern algorithm is used to solve ac-dc optimal reactive power flow model with the generator capability limits. In [18-20] proposes a two-step approach to calculate Reactive power reserves with respect to operating constraints and voltage stability. This paper proposes Hybridization of chaos optimization algorithm with outlook algorithm (HCO) to solve optimal reactive power dispatch problem. Chaos is a worldwideoccurrenceremaining in many systems in all areas of science [21]. It has three keyvibrant properties: the inherent stochastic property, ergodicity and regularity [22]. A chaotic movement can go through every state in a certain area bestowing to its own regularity, and every state is attained only one. Taking benefit of chaos, a new penetrating algorithm called chaos optimization algorithm (COA) is presented [23]. The COA has the lack of the sensitive dependence on preliminarycondition;minute difference in preliminary value, there may be carrying totally searching process. Some states may be reached costing longer time. Parallel chaos optimization algorithm was projected to solve this problem by searching synchronously from several preliminary points [24].While, further research show that this method has the inferior searching efficiency near the optimum point due to stochastic property of chaotic movement [25]. Outlook algorithm is proposed according to common knowledge that one chooses the highest point of mountains by outlook. It can solve global optimization problem by engaging supervision mechanism of outlook, policies of generating outlook points and mechanisms of building and solving local problems [26]. Outlook algorithm has great rate of convergence, fast exploration velocity and strong heftiness. The proposed HCO algorithm has been evaluated in standard IEEE 30 bus test system. The simulation results show that our proposed approach outperforms all the entitled reported algorithms in minimization of real power loss.

II. PROBLEM FORMULATION

The OPF problem is considered as a common minimization problem with constraints, and can be written in the following form:

Minimize f(x, u) (1)

Subject to g(x,u)=0 (2)

and

$h(x, u) \leq 0$ (3)

Where f(x,u) is the objective function. g(x.u) and h(x,u) are respectively the set of equality and inequality constraints. x is the vector of state variables, and u is the vector of control variables.

The state variables are the load buses (PQ buses) voltages, angles, the generator reactive powers and the slack active generator power:

$$x = \left(P_{g1}, \theta_2, \ldots, \theta_N, V_{L1}, \ldots, V_{LNL}, Q_{g1}, \ldots, Q_{gng}\right)^T \quad (4)$$

The control variables are the generator bus voltages, the shunt capacitors and the transformers tap-settings:

$$u = \left(V_g, T, Q_c\right)^T \quad (5)$$

or

$$u = \left(V_{g1}, \ldots, V_{gng}, T_1, \ldots, T_{Nt}, Q_{c1}, \ldots, Q_{cNc}\right)^T \quad (6)$$

Where Ng, Nt and Nc are the number of generators, number of tap transformers and the number of shunt compensators respectively.

III. OBJECTIVE FUNCTION

Active power loss

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

$$F = PL = \sum_{k \in Nbr} g_k \left(V_i^2 + V_j^2 - 2V_iV_j\cos\theta_{ij}\right) \quad (7)$$

or

$$F = PL = \sum_{i\in N_g} P_{gi} - P_d = P_{gslack} + \sum_{i\neq slack}^{N_g} P_{gi} - P_d \quad (8)$$

Where gk : is the conductance of branch between nodes i and j, Nbr: is the total number of transmission lines in power systems. Pd: is the total active power demand, Pgi: is the generator active power of unit i, and Pgsalck: is the generator active power of slack bus.

Voltage profile improvement

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

$$F = PL + \omega_v \times VD \quad (9)$$

Where ωv: is a weighting factor of voltage deviation.

VD is the voltage deviation given by:

$$VD = \sum_{i=1}^{Npq} |V_i - 1| \quad (10)$$

Equality Constraint

The equality constraint g(x,u) of the ORPD problem is represented by the power balance equation, where the total power generation must cover the total power demand and the power losses:

$$P_G = P_D + P_L \quad (11)$$

Inequality Constraints

The inequality constraints h(x,u) imitate the limits on components 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, and reactive power of generators:

$$P_{gslack}^{min} \le P_{gslack} \le P_{gslack}^{max} \quad (12)$$

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g \quad (13)$$

Upper and lower bounds on the bus voltage magnitudes:

$$V_i^{min} \le V_i \le V_i^{max}, i \in N \quad (14)$$

Upper and lower bounds on the transformers tap ratios:

$$T_i^{min} \le T_i \le T_i^{max}, i \in N_T \quad (15)$$

Upper and lower bounds on the compensators reactive powers:

$$Q_c^{min} \le Q_c \le Q_C^{max}, i \in N_C \quad (16)$$

Where N is the total number of buses, NT is the total number of Transformers; Nc is the total number of shunt reactive compensators.

IV. PARALLEL CHAOS OPTIMIZATION ALGORITHM

Parallel Chaos Optimization Algorithm (PCOA) was proposed by [24]. Its chief idea is probing the solution space by different numerous group chaos sequences. Firstly, use the carrier wave technique to make optimization variables vary to chaos variables. Secondly, intensify the ergodic area of chaotic motion to the variation ranges of every manageable variable. Finally, use the chaos search method to optimization problem. The process is concise as follows,

Initialization.pre-set n=1:

$$x_{(i,j,n+1)} = 4 * x_{(i,j,n)} * \left(1 - x_{(i,j,n)}\right) \quad (17)$$

Where i= 1,..,p, represents the different preliminary starting points of i classes, j = 1,.., N , articulates the variable number included in the optimized problem, n is the iteration times.

carrying out the primary carrier wave.

The chaos variables are trade in into the optimized variables, furthermore, the change range of the chaos variables are distinctly augmented the corresponding value range of optimized variables.

$$x'_{(i,j,n+1)} = c_{(i,j)} + d_{(i,j)} * x_{(i,j,n+1)} \qquad (18)$$

Where$x_{(i,j,n+1)}$ is chaos variable, $c_{(i,j)}$and$d_{(i,j)}$ are constants,$x'_{(i,j,n+1)}$is variable used for optimized problem.

Carrying out iteration exploration.

In each generation, set the optimal solution of all classes as the existing solution. If no improved solution is found after N searches, the second carrier wave will be implemented according to the following equation:

$$x''_{(j,n+1)} = x_j^* + \alpha * x_{(j,n+1)} \qquad (19)$$

Wherex_j^* is the present solution, α is regulation constant, $x_{(j,n+1)}$is chaos variable.

Execution of iteration search.

If no improved solution is found after M searches, stopping search and output existing optimal solution.

V. OUTLOOK ALGORITHM

Outlook algorithm was proposed by [26] and it is self-possessed by three parts: direction mechanism of outlook, policies of generating outlook points and mechanisms of constructing and solving local problems. It can resolve global optimization problem bestowing to the following itinerary:

1) Compatible basic point by direction mechanism of outlook;
2) Producing outlook point of base point by policies of generating outlook points;
3) Selecting outlook point bestowing to given standard by direction mechanism of outlook;
4) Building the local problem of outlook point and resolving it by local optimization algorithm;
5) After receiving all the solutions of local problems chosen, conforming next base point and initiate a new iteration until satisfying end condition and set out solution.

VI. CHAOS VARIABLES

Tent map has improved ergodicity consistency than logistic map, so the COA based on tent map has improved optimization efficiency. In addition, tent map has simple structure and iteration process is appropriate for computing [27,28]. In this paper chaos variables are produced by tent map. The tent map is defined by:

$$\gamma(k+1) = \begin{cases} 2\gamma(k) & 0 \le \gamma(k) \le 1/2 \\ 2\left(1-\gamma(k)\right) & 1/2 < \gamma(k) \le 1 \end{cases} \qquad (20)$$

After change transforming, it can be articulated as the following equation:

$$\gamma(k+1) = \left(2\gamma(k)\right) \bmod 1 \qquad (21)$$

VII. HYBRIDIZATION OF CHAOS OPTIMIZATION ALGORITHM WITH OUTLOOK ALGORITHM

Initially, using PCOA established on tent map for global exploration. It is easy to touch the region near global optimization solution owing to the ergodicity. Yet, Local searching speed become very slowly and it is difficult to get the high accuracy optimization solution due to the stochastic stuff of algorithm. Thus the outlook optimization algorithm is engaged in the second stage for local search. Extraordinary searching efficiency is obtained after bonding PCOA with outlook algorithm. The technique is presented as follows:

Step i) Initialize chaos variable $\gamma_j^i(0), 0 \leq \gamma_j^i(0) \leq 1, (i = 1,2,\ldots,n\ j = 1,2,\ldots,P)$,by means of stochastic way, which have minor differences. There will produce p×n chaos variables having different track. The positive integers N1, N2 are quantified. Let flag = 1, C = 0, k = 0; where flag is outlook symbol, C is base point counter, kis iteration times.

Step ii) Chaos variable $\gamma_j^i(0)$ is mapped into the variance ranges of optimization variables by the following equation:

$$x_j^i(0) = a_i + \gamma_j^i(0)(b_i - a_i)$$
$$(i = 1,2,\ldots,n\ j = 1,2,\ldots,P) \qquad (22)$$

Let $f_j^* = f\left(X_j(0)\right), X_j^* = X_j(0), f^* = \min(f_j^*), X^* = X_j^*$ .Where X_j^* is the best solution of the j team,X^* is the global best solution.

Step iii) Carry out chaos exploration by using the carrier wave:

$$\gamma_j^i(k+1) = \left(2\gamma_j^i(k)\right) \bmod 1 \quad (23)$$

$$x_j^i(k+1) = a_i + (b_i - a_i)\gamma_j^i(k+1)$$
$$(i = 1,2,\ldots,n\ j = 1,2,\ldots,P) \qquad (24)$$

If $f\left(X_j(k+1)\right) < f_j^*$,

Then $X_j^* = X_j(k+1), f_j^* = f\left(X_j(k+1)\right)$

Else if $f\left(X_j(k+1)\right) \geq f_j^*$,

Then give up $X_j(k+1)$

If min $f_j^* < f^*$

Then $f^* = f_j^*, X^* = X_j^*$

Else do nothing

Let $k \leftarrow k+1$ until f^*does not progress after N1 searches.

Step iv) Set$X^B = X^*$, where X^B is outlook base point.

Step v) If flag = 1 and C < N2, Then carry out Step (vi) or Else go to step (vii).

Step vi) Generating outlook point of base point $X_o^i (i = 1,2,\ldots,m)$ according to strategies of generating outlook points provided by paper [26] .

Step vii) While $f(X_i^o) \leq f(X^B)$ Carry out local search and get local optimum solution X_i^l from the point X_i^o .If min $f(X_i^l) < f(X^B)$ then $X^B = X_i^l$, flag = 1, return to step (vii). Or Else carry out step (viii).

Step viii) Halt the exploration process and put out X* = XB as the best solution, f * = f (XB) as the finest value.

VIII. SIMULATION RESULTS

The validity of the proposed HCO Algorithm technique has been demonstrated in standard IEEE-30 bus system. The test system has six generators at the buses 1, 2, 5, 8, 11and 13 and four transformers with off-nominal tap ratio at lines6-9, 6-10, 4-12, and 28-27 and the number of the optimized control variables is 10 for this reactive power dispatch problem. The minimum voltage magnitude limits at all buses are 0.95 pu. The maximum limit values for generator buses are 1.1pu &1.05 pu for the remaining buses .The minimum and maximum limits of the transformers tapping are 0.9 and 1.1 pu. The optimum control parameter settings of the proposed HCO approach are given in Table 1 and Table 2&3 shows the comparison of power loss and voltage deviations. Form the simulation, the most excellent value of active power loss is 4.422573. The voltage deviations obtained from proposed HCO approach 0.103542 respectively.

Table 1. Optimum control parameters values

Control Variables setting	Case 1: Power Loss	Case 2: Voltage Deviations
VG1	1.03	0.90
VG2	1.01	0.91
VG5	1.00	1.04
VG8	1.00	1.03
VG11	1.01	1.01
VG13	0.91	1.02
T6-9	1.03	0.91
T6-10	1.00	1.01
T4-12	1.01	1.02
T27-28	1.01	0.90
Power loss (MW)	4.422573	6.279014
Voltage deviations	0.721889	0.103542

Table 2: Comparison of the Resultsfor active Power Loss

Control Variables Setting	HCO	GSA [29]	Individual Optimizations [30]	Multi Objective EA [30]	As Single Objective [30]
VG1	1.00	1.049998	1.050	1.050	1.045
VG2	1.02	1.024637	1.041	1.045	1.042
VG5	1.02	1.025120	1.018	1.024	1.020
VG8	1.01	1.026482	1.017	1.025	1.022
VG11	1.00	1.037116	1.084	1.073	1.057
VG13	0.91	0.985646	1.079	1.088	1.061
T6-9	1.00	1.063478	1.002	1.053	1.074
T6-10	1.00	1.083046	0.951	0.921	0.931

T4-12	1.01	1.100000	0.990	1.014	1.019
T27-28	1.01	1.039730	0.940	0.964	0.966
Power Loss (Mw)	4.422573	4.616657	5.1167	5.1168	5.1630
Voltage Deviations	0.721889	0.836338	0.7438	0.6291	0.3142

Table 3: Comparison of the Resultsfor voltage deviations

Control Variables Setting	HCO	GSA [29]	Individual Optimizations [30]	Multi Objective EA [30]	As Single Objective [30]
VG1	0.92	0.995371	1.009	1.016	1.021
VG2	0.90	0.950069	1.006	1.012	1.021
VG5	1.01	1.043033	1.021	1.018	1.021
VG8	1.01	1.021292	0.998	1.003	1.002
VG11	1.02	1.100000	1.066	1.061	1.025
VG13	1.02	1.062669	1.051	1.034	1.030
T6-9	0.90	0.905907	1.093	1.090	1.045
T6-10	1.00	1.035611	0.904	0.907	0.909
T4-12	1.03	1.038107	1.002	0.970	0.964
T27-28	0.91	0.925607	0.941	0.943	0.941
Power Loss (Mw)	6.279014	6.371609	5.8889	5.6882	5.6474
Voltage Deviations	0.103542	0.106498	0.1435	0.1442	0.1446

IX. CONCLUSION

In this paper, theHCOhas been successfully implemented to solve Optimal Reactive Power Dispatch problem. The proposed algorithm has been tested on the standard IEEE 30-bus system. Simulation results indicate the toughness of projected HCO approach for providing better optimal solution in reducing the real power loss. The control variables obtained after the optimization by HCO is within the limits.

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