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Applying Chaotic Optimization Algorithm for Optimal Power Distribution

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Abstract – A new method based on Chaotic Optimization Algorithm (COA) is presented for optimized load distribution and to minimize the expenditures .The presented method is simulated on a standard IEEE -30bus system. Results obtained demonstrate that the algorithm has great potential in functions optimization. Moreover, the results of this algorithm are compared with the results of other methods of evolutionary algorithm. The aim of distributing the power optimized distribution is to minimize the power production costs and to optimize allocation of every plant share in addition to providing the required power for a network. An inferior purpose function is expressed via the basis of units' productive power and restrictions are modeled in the form of linear equalities and inequality Equation. Various methods are presented for the analysis of this problem and each method has its own special restrictions. First of all, different methods are introduced on the basis of linear schematization and then disadvantages of each method is discussed. Among the various offered methods, those based on evolutionary algorithm were more successful.

Key words: Chaotic Optimization Algorithm (COA), Power Distribution, IEEE -30bus system.

INTRODUCTION

Nowadays dominant rules of countries' electricity industry have changed thus competition opportunity in production and electric energy consumption is being provided beforehand. Power systems require special tools to analyze, monitor and optimum controlling different aspects of exploitation and schematization. Most of these tools are formulated properly in the form of optimization problems.

We can determine different active and reactive powers compounding for powerhouse units in order to feed load .What is more crucial for the load optimum distribution viewpoint is to find an economical compounding. Due to the power production which is the main part of production cost in the power system of powerhouses, the most important thing to determine system's different powerhouses share in the power production which minimizes production expenditures.

The main purpose is to find optimum adjustments for a power system in a way that provides definite purpose function and other restrictions such as load distribution equation and system exploitation limitation; it's formulated base upon optimum equal load distribution in the power system. One of the most important purposes of electric companies is to generate electric energy and transmission and distributing it among consumers with high reliability and minimum exploitation's costs. Before introduction the concept of power system security, load distribution problem focused more on economic problems of exploitation rather than systems security. Nowadays with expansion of power systems and increasing system load, compounding security restrictions with concept of optimum load distribution has become an important issue. Plenty of methods have been presented to solve load distribution. Majority of them are based on linear programming and Newton-Raphson methods. One of the most important merits of these methods is their consistency with the existing economical distribution programs. Many traditional optimization techniques are applied for solving the optimum load distribution problem and one of the most important techniques is linear programming, sequencing second hand programming method, generalized decreasing geradian decreasing and Newton-Raphson method.

In this paper, an optimization-based tuning algorithm is proposed to optimum load distribution problem. This algorithm optimizes the total system performance by means of COA method. Chaos is a kind of characteristic of non-linear systems which is a bounded unstable dynamic behavior, which exhibits sensitive dependence on initial conditions and include infinite unstable periodic motions. The COA is based on ergodicity, stochastic properties and regularity of chaos. It is not like some stochastic optimization algorithms that escape from local minima by

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accepting some bad solutions according to a certain probability but COA searches on the regularity of chaotic motion to escape from local minima (Coelho, L. D. S, 2007), (Yan, X. F., *et al*. 2003).

Introduction Of Load Optimum Distribution Problem:

First link in the load optimum distribution problem is energy conservation maxim.

$$P_D = \sum_{i=1}^{n_g} P_{gen} = P_{load}(i) + P_L \tag{1}$$

P_D =Demanded Power

$P_{gen}(i)$: Generative power by generator i

$P_{load}(i)$: Consumption power by load i

P_L : Wasting power in transmission lines

n_g : Numbers of existing generators of system

n_i : Numbers of existing load in system

Link 1 expresses that sum of productive power equals with sum of consumed power including consumed power in loads and wasted power in transmission path. This relation is expressive of energy conservation law.

We should notice that production capacity of every generator is low and every generator includes the limitation of extreme production.

Production of every generator cannot decrease to any measure for some special problems of power stability. Therefore there are two minimum and maximum limitations for productive power of every generator that is presented as relation 2 in this way:

$$P_{gen(i)\min} \le P_{gen(i)} \le P_{gen(i)\max} \tag{2}$$

In the first relation P_L is expressive of wasted power in transmission lines. We can obtain the wasting numbers in transmission lines with using the kerun relation. We can calculate the wasting extent with using relation 3.

$$P_L = \sum_{i=1}^{ng} \sum_{i=1}^{n_g} P_i B_{ij} P_j + \sum_{i=1}^{n_g} B_{Oi} P_j + B_{OO} \tag{3}$$

We can calculate total costs of power production with sum of power production costs in every generator. Therefore we can easily calculate total costs of power production with relation 4.

$$C_t = C_1 + C_2 + ... + C_{ng} \tag{4}$$

We can obtain the production cost of every powerhouse on the fuel cost curve of every powerhouse. Fuel costs curves are estimated for simplify with second hand multi sentence and are presented in the form of relation 5.

$$F(P_i) = \sum_{i=1}^{n_g} (a_i + b_i p_i + c_i p_i^2) \Big/ hr \tag{5}$$

Where a, b, and c are constant coefficient of cost function, P_i is the production power of every generator.

Linear programming: Linear programming (LP) in mathematics is a technique for function optimization of linear purposes with pay attention to linear equal and unequal restrictions. Linear Programming specifies the method of reaching to best result for mathematics model.

$$f(x_1, x_2, ..., x_n) = c_1 x_1 + c_2 x_2 + ... + c_n x_n + d \tag{6}$$

Linear programming finds a point at the multi sentence function that include minimum (or maximum) extent and such point maybe never exist but if it exists, searching by the peak of function boundaries guarantee to find at least one of them.

The linear programming problems can be expressed in the focal form:

Maximize $C^T x$, $\quad Ax \le b$ (7)

Where x is variables vector (should be determined), whereas c and e are apparent coefficient vector and A is coefficient matrix. First phrase is our purpose function that should be maximized and the second phrase are our equations and restriction that draw kanoksi boundaries for purpose function and purpose function should be optimize on these boundaries . Linear programming should be applied in wide variety of fields. It has been applied more in economical conditions. But it can be used in some engineering problems. Industries which apply linear programming models include transportation industry, energy, communication and production industries.

In spite of their excellent convergence features and their high application in industry, some of their weakness is as follow:

1. Convergence to precise or local solution depends on primary guess.
2. Every technique fits for an special load distribution problem based on mathematical nature of purpose function.
3. They have been expanded based on some theoretical assumption such as being convex, derivation, affinity that maybe doesn't fit for real condition of this assumption.

Chaotic Optimization Algorithm:

Chaos often exists in nonlinear systems. It is a kind of highly unstable motion of deterministic systems in finite phase space. An essential feature of chaotic systems is that small changes in the parameters or the starting values for the data lead to vastly different future behaviors, such as stable fixed points, periodic oscillations, bifurcations, and periodicity. This sensitive dependence on initial conditions is generally exhibited by systems containing multiple elements with nonlinear interactions, particularly when the system is forced and dissipative. Sensitive dependence on initial conditions is not only observed in complex systems, but even in the simplest logistic equation (Coelho, L. D. S, 2007). The application of chaotic sequences can be an interesting alternative to provide the search diversity in an optimization procedure. Due to the non-repetition of chaos, it can carry out overall searches at higher speeds than stochastic argotic searches that depend on probabilities (Liu, B., Wang, *et al*. 2005). The design of approaches to improve the convergence of chaotic optimization is a challenging issue. The simple philosophy of the COA includes two main steps: firstly mapping from the chaotic space to the solution space, and then searching optimal regions using chaotic dynamics instead of random search (Liu, B., Wang, *et al*. 2005). This chaotic map involves also non-differentiable functions which difficult the modeling of the associate time series. The Lozi map is given by (Coelho, L. D. S, 2007):

$$y_1(k) = 1 - a \times |y_1(k-1)| + y(k-1) \tag{8}$$

$$y(k) = b \times y_1(k-1) \tag{9}$$

$$z(k) = \frac{y(k) - \alpha}{\beta - \alpha} \tag{10}$$

Where, k is the iteration number. In this work, the values of y are normalized in the range [0,1] to each decision variable in n-dimensional space of optimization problem. Therefore, y_1 ε [-0.6418, 0.6716] and [α, β] = (-0.6418, 0.6716). The parameters used in this study are a = 1.7 and b = 0.5, these values suggested by (Caponetto, R, *et al*. 2004). Many, unconstrained optimization problems with continuous variables can be formulated as the following functional optimization problem.

Find X to minimize f(X), X= [x_1, x_2, …, x_n].

Where, f is the objective function, and X is the decision solution vector consisting of the n variables, x_i, bounded by lower (L_i) and upper limits (U_i). Figure 1 shows the flowchart of the proposed chaotic search procedure based on the Lozi map.

Where f is the objective function, and X is the decision solution vector consisting of n variables, x_i, bounded by lower (L_i) and upper limits (U_i). M_g and M_L are maximum number of iterations of chaotic Global search and maximum number of iterations of chaotic Local search, respectively. In this paper λ is step size in chaotic local search and linearly decreases from 0.1 to 0.01. Also, $\bar{f}$ and $\bar{X}$ are best objective function and best solution from current run of chaotic search, respectively.

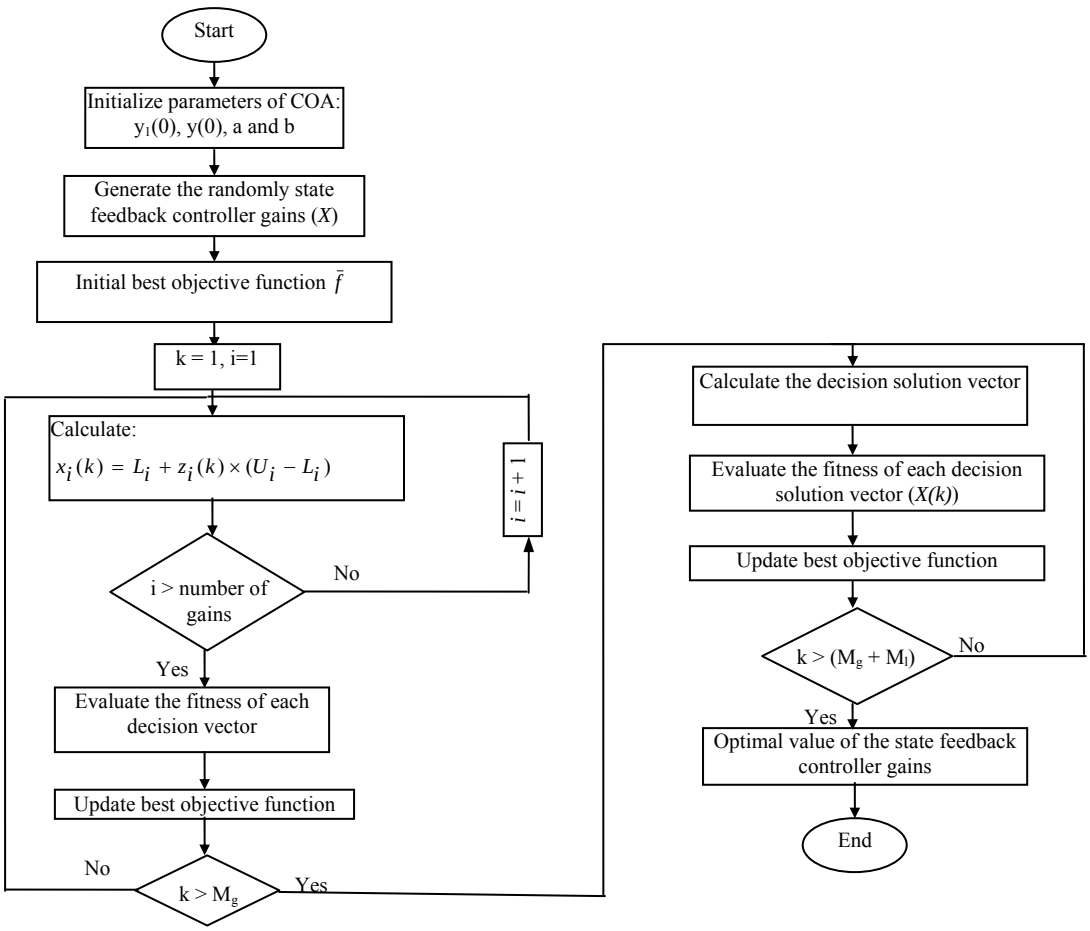

Fig. 1: Flowchart of the proposed COA.

VI. Simulation Results:

We apply optimization method with using Chaotic Optimization Algorithm (COA) to the standard 30 Bus-IEEE Network. This network is a real network in the electric system of america Midwest state(1961).

This network includes 6 generator, 6 transformer and 41 transmission line and 2vectorial transmission line in 33 and 132 voltage kilowatt. High and low restriction of transformer are respectively 1/1 and 0/9 pu . the ranking of condensor bank is regulated between 0 to 20 Mvar. The generators features are specified in table 1. and in this table a.b.c are constant values of second hand cost function that we can esmtimate for high degree multi sentenses . Pmax and p minare maximum and minimum production power of every generator. Table 2 shows the obtained results. in the column number 2,the mentioned results are written in 4 number reference thatis obtained by the genetic alghorithm . In the column number 3 mentioned results written in the refrence number 4 are obtained with using optimization algorithm of particle group . in the column number 4 the obtained results of suggested method is showned by using COA .

Obtained total costs for each assumed generator for applied method is specified at last line with considering the productive power of each generator .

COA efficiency and its accuracy specifies by considering obtained values for total costs.

Table I: Generators Features

Number	Bus	a	b	c	Pmin	Pmax
1	30	100	200	10	0.05	1.5
2	29	120	150	10	0.05	1.5
3	28	40	180	20	0.05	1.5
4	27	60	100	10	0.05	1.5
5	26	40	180	20	0.05	1.5

6	25	100	150	10	0.05	1.5

Table II: Results Comparison

Generator	Generator production in (B. S. Kermanshahi, *et al*. 1990)	Generator production in (M. R. Alrashidi., & M. E. El-Hawary. 2003)	Generator production in the given method
1	0.15	0.124	0.138
2	0.3	0.31	0.291
3	0.55	0.543	0.538
4	1.05	1.016	1.033
5	0.46	0.514	0.512
6	0.35	0.353	0.348
Total Cost	606.14	606.04	605.73

Figure 2 represents costs function convergence based on restrictions and restrictions are modelized in the form of linear equal and unequal equations. Whatever repetition be more , costs function number decrease and converge toward the best answer. Figure 3 shows the productive power based on per unit by each generator in the suggestive method that the most productive power relates to 6th generator and productive power belongs to the first generator according to the figure.

The problem's restrictions are regarded completely and sum of gained powers is also 2/86 pu.

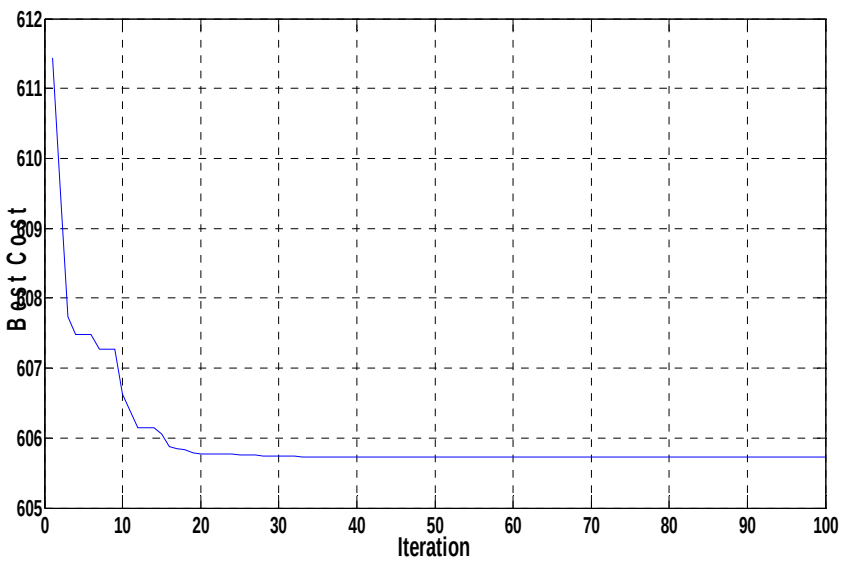

Fig. 2: Changes of costs function.

Conclusion:

To distribute optimized load in the power system (according to its high speed and its proficiency in the power system) Chaotic Optimization Algorithm (COA) is applied .this algorithm clogs less in the local minimums, thus it requires purpose function that leads to high speed , this algorithm also has less complexity which results in solving time problem. Proper purpose function is introduced, and the results show decreasing power production costs according to problems restrictions. The results show that the algorithm acts successfully in finding optimized points of the system. Of course these solutions can also be obtained by simulation on the bigger networks that are not included in this article. Mentioned optimization strategy can be applied in solving engineering problems successfully, along with other common optimization methods such as genetic algorithm, and optimization of particle group.

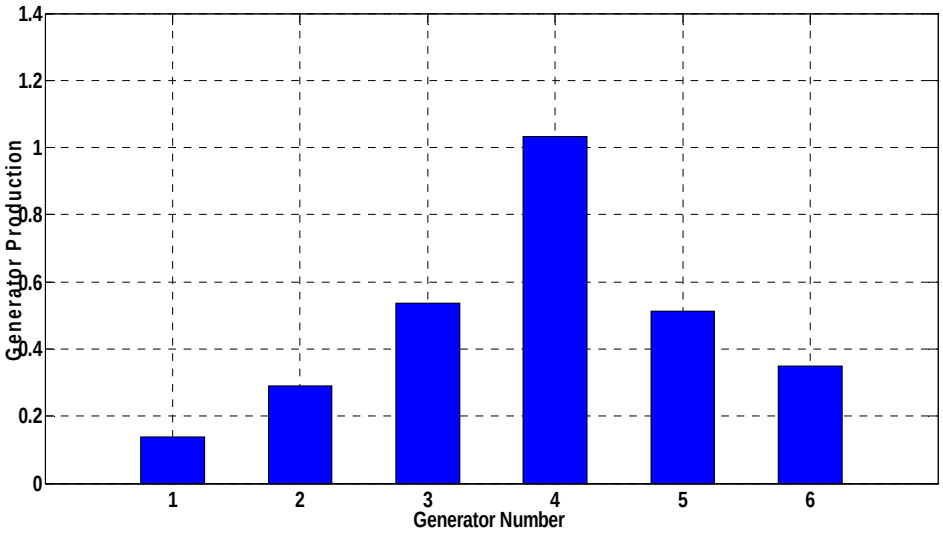

Fig. 3: Production measure of each generator.

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