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Using A New Advanced Intelligent Algorithm for Optimal Power Distribution

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Abstract: In this article a new method based on Imperialist Competitive Algorithm is presented for optimized load distributionin order to minimizing the expenditures. The suggested method is applied on a standard 30bus- IEEE. The obtained result, signify that this algorithm has great potency for the optimization of functions and the obtained result of this algorithm is compared with the obtained result of other methods of evolutionary algorithm. The purpose of distributing the power optimized distribution is minimizing the costs of power production with the optimum allocation of every POWERHOUSE share in addition of providing the required power for network. An inferior purpose function is expressed on the basis of productive power of the units and the restriction are modeled in the form of linear equal inequality and inequality EQUATION. Many methods is presented for analysis of this problem and each of these methods has special restrictions. At first various methods is introduced on the basis of linear schematization and then disadvantages of each of these methods is surveyed. Among the various offered methods, the methods in which were on the basis of evolutionary algorithm included great succession.

Key words: Imperialist Competitive Algorithm, Power Distribution,

INTRODUCTION

Nowadays the structure of dominant rules on the different countries's ELECTRICITY industry' is changed so that the competition possibility in production and consuption of electric energy is being provided beforehand. power system requires special tools in order to analysising the monitor and optimum controling of different aspects of exploitation and schematization.most of these tools are formulated properly in the form of optimization problems.

We can determine different compoundings of active and reactive powers for powerhouse units in order to feeding load .the most important thing point for the load optimum distribution viewpont is that we find which compounding is more economical.

Due to the fact that the main part of production cost in the power system belongs to the power production in the powerhouses so the most important thing in this discussion is determining the share of system's different powerhouses in the power production in the way the production expenditures minimizes.

The main purpose is finding optimum adjustments for a power system in the way it provides definite purpose function and other restriction such as load distribution equations and limitation of system exploitation; it will be formulated base on optimum load distribution equals in the power system. One of the most important purpose of electric companies is generating electric energy and its transporting and distributing between consumers with high reliability and minimum exploitation's costs. Before introduction the concept of security's power system, the problem of load distribution focused more on the economic problems of exploitation rather than system 's security. Nowadays with the expansion of power systems and increasing the systems 's load, compounding the security restrictions with the concept of optimum load distribution has been important problem.

Many Methods has been presented for solving the load distribution and 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 has been applied for solving the optimum load distribution problem and one of the most important techniques are linear programming, sequencing second hand programming method, generalized decreasing geradian decreasing and Newton-Raphson method.

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Rapid growth and expansion of recent computational intelligent tools led the scientists to use them for variable problems of optimum load distribution.

Introduction of load optimum distribution problem:

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

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

P_D =Demanded Power
$P_{gen(i)}$: generative power by generator i
$P_{oad}(i)$: consumption power by load i
P_L: wasting power in transmission lines
n_g: numbers of existing generators of system
n_l: 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 limitation 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.

$$P_L = \sum_{i=1}^{n_g} \sum_{i=1}^{n_g} P_i B_{ij} P_j + \sum_{i=1}^{n_g} B_{oi} P_i + B_{oo} \tag{3}$$

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.

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

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.

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

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 specify the method of reaching to best result for mathematics model.

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

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:

$$\text{Maximize} \quad c^T x , \qquad\qquad Ax \le b \tag{7}$$

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 are 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 these assumptions.

ICA algorithm introduction;

In this article the imposed algorithm for optimization, that is inspired from mathematics modeling of imperialist competition ,has been introduced and its different component will be explained. We want find the argoman x in the way its analogous cost be optimum, with having function in optimization.

In this article, new algorithm is introduced for general searching that is inspired from imperialist competition. In sum this algorithm starts in several countries at the early stage. In fact countries are possible answers of problems and are chromosome equals in genetic algorithm and particle in optimization of particle group. All the countries are divided into two parts: imperialist and colony. Imperialistic countries absorb colony countries with applying simulation policies parallel with different axis of optimization.

Imperialist competition along with assimilation policy forms the main nucleus of this algorithm and causes the countries to move in the absolute minimum of function.

ICA algorithm:

Figure 1 shows ICA algorithm flowchart. This algorithm, such as other evolutionary algorithms begins with some accidental primary crowds that each of them has been called a "country". Some of best elements of crowds are selected as imperialist (equal with elites in genetic algorithms). the remaining crowds have been considered as colony. Imperialist, with their power, absorb these colonies to themselves with special trend that will be discussed at future.

Power of each empire depends on its two constitutive part namely imperialist country (as central nucleus) and its colonies. In mathematics this dependence models with empire power definition in the form of power sum of imperialist country plus percents of average power of its colonies. The imperialist competition between them begins with forming early empires. Each empire that cannot be successful in imperialist competition and increases its power, will be removed from imperialist competition scene. therefore the survival of each empire depends on its power in absorption of revival empire's colonies and ruling over them. As a result, in imperialist competition streams, the power of greater empires will be increased and weak empires will be removed. Empire will be obliged improve their colonies for increasing their power.

Colonies gradually near the empires and we can observe some sort of convergence. Final extent of imperial extent is when we have had unit empire in the world, with colonies which are close to the imperialist country accordance with their position.

For starting the algorithm, we create N numbers of early countries. we select N imp of the best members of this crowd as imperialist (the countries including minimum amount of cost function), the remains forms N col of colonies countries in which each of them belongs to one empire. We give some of these colonies to each imperialist for dividing the early colonies among the imperialist accordance with their power. consider their normalized cost as follow:

$$C_n = \max\{c_i\} - c_n \tag{9}$$

Where C_n imperialist cost max (C_i) is highest cost among imperialist and C_n is normalized cost of this imperialist.

Each imperialist which have had more cost (be weaker imperialist), includes less normalized costs. Normalized respective power of each imperialist, with having normalized costs, has been calculated as follow and accordance with it, colonies countries have been divided between imperialist.

$$P_n = \frac{C_n}{\sum_{i=1}^{N_{imp}} C_i} \tag{10}$$

From other respect, normalized power of an imperialist is colonies proportion that are controlled by that imperialist.Therefore the early number of an imperialist's colonies equals with:

$$N.C.n = \text{round}\{P_n.(N_{col})\} \tag{11}$$

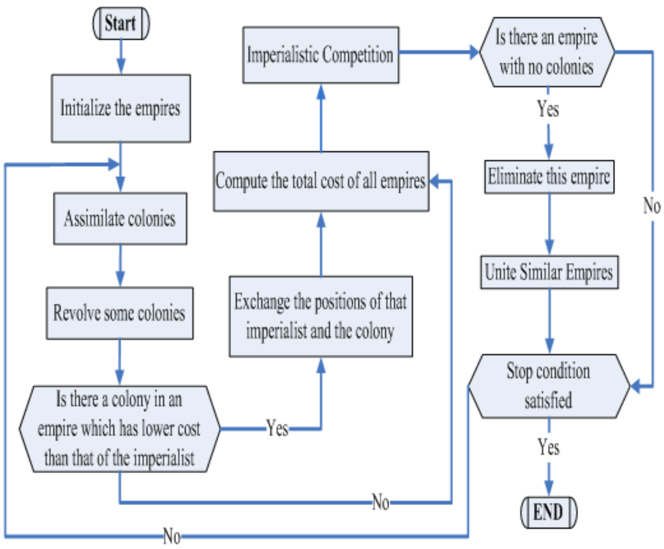

Fig. 1: Flowchart of the Imperialist Competitive Algorithm

Where N.C.n is early number of empire 's colonies and N_{col} is the total number of existing colonies countries in the early countries crowds . Round is also function that give closest integer t a decimal number. We select accidentally some of these primary colonies countries, with considering N.C for each empire an give it to N imperialist, the imperialist competitive algorithm begins with having primary status of all empires. Evolutionary trend which located in a segment that continues till the stop condition fulfillment. figure 2 shows the manner of early empires forming. Bigger empires have more colonies. In this figure, imperialist number 1 creates the strongest empire and have most number of colonies.

Colonies movement toward the assimilation policy of imperialist has done with the purpose of analyzing the culture and social structure of colonies in central government culture. Imperialist countries began to creating development (building transportation substructure , university establishing ,…). In fact this central government tries to close colony country to its self by applying attraction policy, in different political and social dimensions, with considering showing manner of country in solving optimization problem. This section of imperialistic process in optimization algorithm has been modeled in the form of colonies movement toward the imperialist country. The figure 3 shows total image of this movement.

Absorption policy modeling:

According with this figure, imperialist country attract to itself parallel with culture and language axis. As shown in this figure, colony country moves in x unit size toward the attachment line of colony to the imperialist and drawn to new situation.

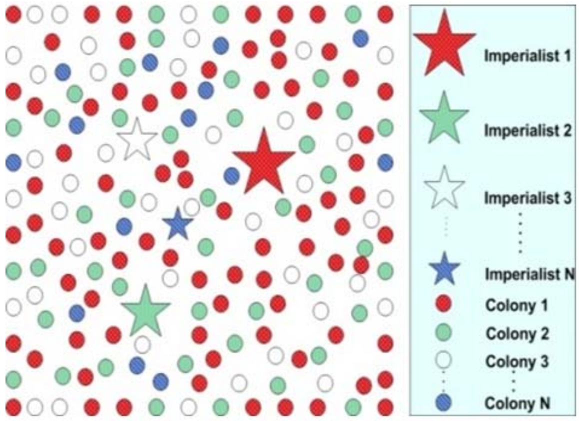

Fig. 2: Manner of forming primary empire, imperialist number 1 creates strongest empire and has maximum number of colonies.

In this figure, distance between imperialist and colony is shown by D, and x is accidental number with steady distribution.

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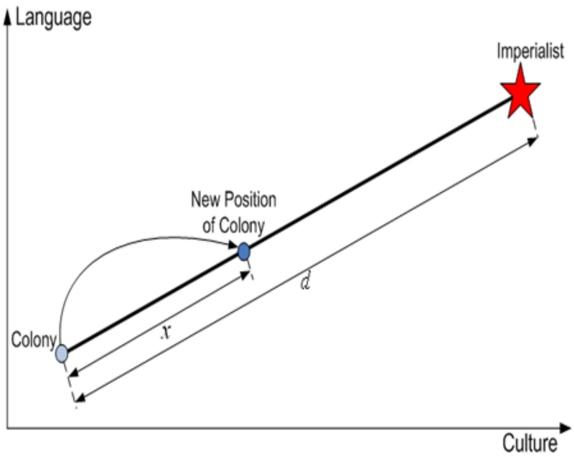


Fig. 3: total image of colony movement toward imperialist.

It means for x, we have:

$$x \sim U(0, \beta \times d) \tag{12}$$

Where β is a number bigger than 1 and nears to 2. A good selection can be β=2. The existence of coefficient β 1 causes the colony country closes to the imperialist country from different aspects while moving.

With historical survey of assimilation phenomena, one clear fact in this field is in spite that imperialist countries followed seriously the attraction policy but facts did not follow totally accordance with applied policy and there were deviances in the work results. In introduced algorithm, this probable deviation has done with adding an accidental angle to the attraction path of colonies. For this purpose, in the colonies movement toward the imperialist, we add an accidental angle toward the colony movement, figure 4 shows this state. this time we continue our path in stead of x movement toward the imperialist and in toward the vector and colony maxim to the imperialist in the same extent, but with θ deviation in the path, and consider θ accidentally and with constant distribution (but any ideal and proper distribution can be used), then $\theta \sim U(-\gamma,\gamma)$. In this relation y is ideal parameter that its increasing causes increasing searching around imperialist and its decreasing causes colonies close possibly to the vector of connecting colony to the imperialist. With considering the radian unit for θ, a number close to $\pi/4$ was proper selection in the most depletion.

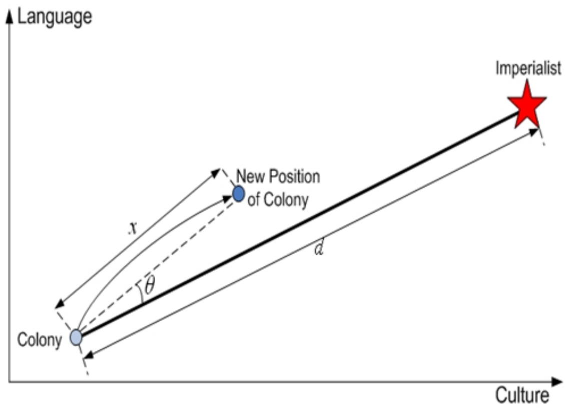


Fig. 4: real movement of colonies toward the imperialist.

3. Position displacement of colony and imperialist:

In some cases attraction policy has had possitive result for them, in spite of destroying political-economical structures of colony countries. some of countries with appling this policy accessed to general self confidence and after awhile it was the educated people who combat with the nation leadership for escaping from imperialist. We can find various cases of these in enland and france' s colonies. from other perspective, looking at up and downs of power circulation in the countries shows truly that the countries in which were at the peak of politic military powr, after awhile declined and contrary the countries reached to the power that before hadnt were not into the power. This historical movement in the modelling in the itroduced alghorithm has been applied in the way of colony movement toward the imperialist country, some of these colonies may reach to a better condition than imperialist (reaching to the points in cost fuction that generate less costs than cost function extent). In this state, the imperialist country and colony change their position and algorithm continues with imperialist counry in new situation and this time it is the new imperialist country in which begin to applying assimilation policy for its colonies. The colony and imperialist displacement is shown in the figure 5. In this figure the best empire's colony in which has less costs than imperialist, is shown with dark colour. figure 6 shows the whole empire after position changing.

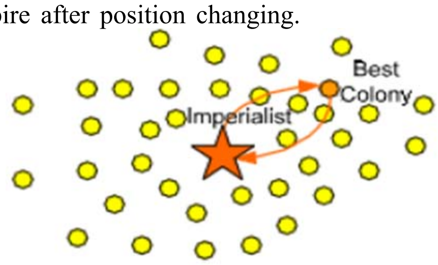


Fig. 5: displacement of colony and imperialist

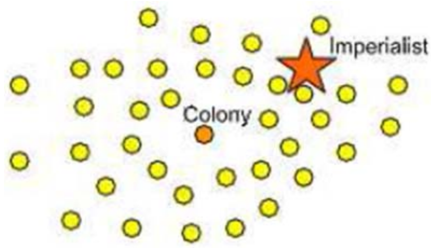


Fig. 6: the whole empire after displacement

4. Total Power of an Empire:

The power of an empire equals with the power of imperialist country in addtion to some perceptage of total power of whole colonies, in this case the total cost of an empire calculate as follow:

$$T.C.n = Cost(imperialist) + \zeta mean\left\{cost\left(colonies\ of\ empire\right)\right\} \tag{13}$$

Where T.C.n is the empire's total cost and ζ is possitive number that is usually between zero and one and near to zero.This low considering of ζ cause total cost of empire be nearry equal with its central government and inreasing ζ causes increasing the colonies's costs measure infulunce of an empire in determining the its total costs. In generic state ζ =0/ 05 in the most cases reulted to proper answers.

4. 1 Imperial competition:

Each empire which cannot increase its power and looses its competiton power, will be removed from imperialistic competitions. this removing forms gradually. it means that with passing the time, weak empire give up their colonies and the strong empire take possession of these colonies and increase their power . for modelling this fact, we assume the empire at the time of deleting, is the weakest existing empire. So in the algghorithm repetition, we take some of weakest colonies of the empire and create a competition between the whole empires . mentioned colonies will not nessesarily be possessed the strongest empire. But this is the stonger empire which has more chance for its ownership. figure 9 shows total image of this part of alghorithm.

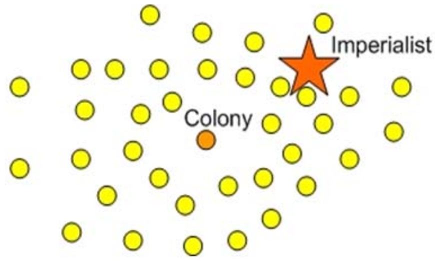


Fig. 7: Exchanging the positions of a colony and the imperialist

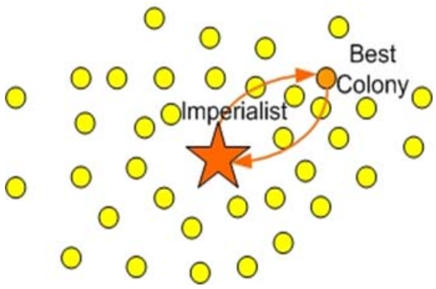


Fig. 8: The entire empire after position exchange

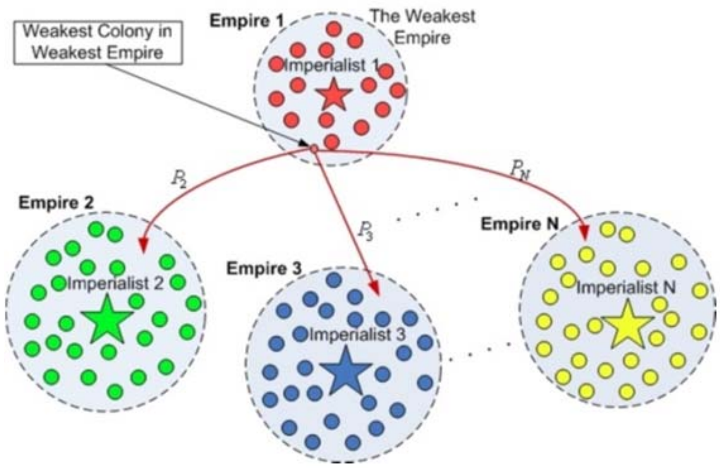


Fig. 9: total image of imperialistic competition : bigger empire take the possession oof the other emire's colonies with more liklihood.

For modelling the competition between the empires for possessing these colonies, first of all we calculate the owenership probability of each empire(that be fit with the power of that empire) with considering total cost of each empire, as follow: first we determine total costs of empire based on its nnormalized costs:

$$N.T.C._n = T.C._n - \max_i \{T.C._i\} \tag{14}$$

Where T.C.N is n total cost of empire and N.T.C.n is normalized costof that empire. Each emire which have had less T.C.N ,has more n.t.cn . infact T.C. n equals total cost of an empire and N.T.C. N equalsits total power. the probability of colony ownership in competition by each empire calculates as follow:

$$p_{p_n} = \left| \frac{N.T.C._n}{\sum_{i=1}^{N_{imp}} N.T.C._i} \right| \tag{15}$$

with ownership probability of each empire, we divide the mentioned colonies accidentally between the empires, but with related probability to ownership probability of each empire. Then we form vector P based on above probabiliy extents as follow:

$$\mathbf{P} = \left[p_{p_1}, p_{p_2}, p_{p_3}, ..., p_{p_{N_{imp}}} \right] \tag{16}$$

vector P' s size is 1×nimp and is consituted based on probability amounts of empires ownership. Then we form the accidental vector R as equal as vector P, the arrays of this vector are accidental number with the same distribution in baze [0.1].

$$R = \left[r_1, r_2, r_3, ..., r_{N_{imp}} \right]$$
$$r_1, r_2, r_3, ..., r_{N_{imp}} \sim U(0,1) \tag{17}$$

Then we form vector D as follow:

$$\mathbf{D} = \mathbf{P} - \mathbf{R} = \left[D_1, D_2, D_3, ..., D_{N_{imp}} \right]$$
$$= \left[p_{p_1} - r_1,\ p_{p_2} - r_2,\ p_{p_3} - r_3\ , ...\ , p_{p_{N_{imp}}} - r_{N_{imp}} \right] \tag{18}$$

We give the mentioned colonies to the empires with having vector D so that related andis in vector D be bigger than others. The empire which has more ownership probability, has the highest extent ,with more chances in related and is in vector D.

4. 2 Declining the weak empires:

Weak empires gradully decline in imperialistic competition and strong empires take the possession of their colonies. There are different conditions for declining an empire. In suggested empire, when an empire loose its colonies, it assumped deleted.

4.3 Convergency:

The mentioned alghorithm continues till fulfillment of one convergency condition or afinishing the number of whole repitition. After awhile all the empires will decline and we have only one empire and other countries are under the control of this united empire.

In this new ideal world all the colonies are controled bye an united empire and the colonies 's cost and situations equals with the empirilaist 's cost and situation. in this new world, there are no difference not only between colonies but also between colonies and imperialist country. in other words, all the countries are both colony and imperialist at the same time. In such situation the imperialistic competition have been finished and stops as one stop codition of algorithm.

5. ICA Alghorithm:

Assimilation: this function applies assimilation part or in other word attraction policy.

Primary empires: it forms primary empires with proper dividing of colonies among them, with concidering situation and cost of primary countries.

Imperialistic competition: The imperialistic competition between the emipres in order to attract each other colonies is done by this function. removing the weak empires is also in this function.

Imperialist and colony displacement: Displacement of imperialist and colony is done in this function. If a colony reach to a better position than imperialistt, it immediately take the control of emperor and continues the work with applying the attraction policy on them.

The colonies revolution: Revelution, that is main counterweight of discovery balance and exploitation and is useful for discovery ,applies in this function. sudden changes happens in some countries and in some cases leads to discovery of minimum indiscernible point in function.

5. 1 ICA alghorithm's similar_code:

1.select some accidental point on the function and form the primirary empires. we mean the powerhouses power that are concidered as primary guess.

2.move the colonies toward the imperialist country (assimilation policy).

3. if there are an empire that has less costs than imperialist ,change the position of colony and imperialist.

4. calculate total costs of an empire(with pay attention to imperialist and its colonies's costs).

5. select one colony from weakest empires an give it to the empire which has more chance for ownership.

6. delete weak empires.

7.stop if there are only one remained empire, otherwise go to 2.

5. 2 Assimilation Results:

We apply optimization method with using ICA alghorithm to the standard 30 Bus- IEEE Network according figure 10. 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. Appling ICA algorithm parameter calculation defines as follow:

1. Number of countries:1000
2. Number of imperialists:20
3. Number of colonies :800
4. Repetition numer :1000
5. The percentage of colonies revelution :0/4
6. Assimilation:2

We repeated this alghorithm 40 times that led to best results with earned parammeter above.

Table 2 shows the obtained results. in the column number 2, the mentioned results aare 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 ICA alghoritm.

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

Time of completing ICA alghorithm process for mentioned problem is about 2.5 minutes that is shorter than genetic alghorithm and optimization alghorithm of particle group. ICA efficiency and its accuracy specifies by considering obtained values for total costs.

Table 1: Generators Features

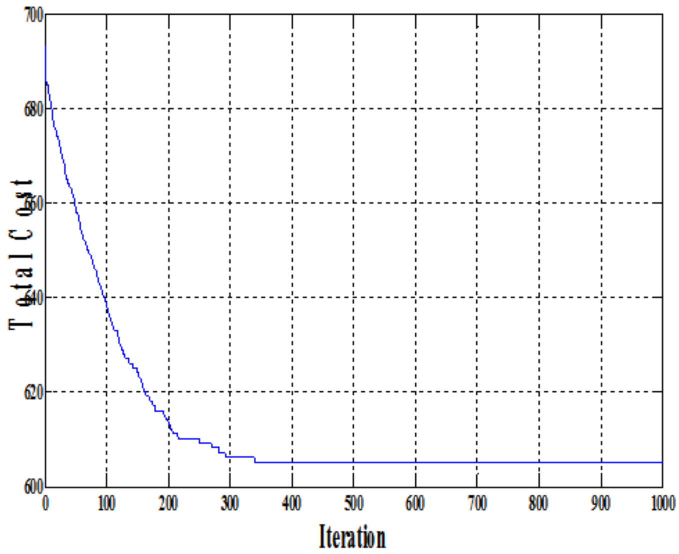
Pmax	Pmin	c	b	a	Bus	Number
1.5	0.05	10	200	100	30	1
1.5	0.05	10	150	120	29	2
1.5	0.05	20	180	40	28	3
1.5	0.05	10	100	60	27	4
1.5	0.05	20	180	40	26	5
1.5	0.05	10	150	100	25	6

Table 2: Results Comparison

Generator production in the given method	Generator production in reference (Alrashidi and El- Hawary)	Generator production in reference (Yokoyama *et al.,* 1988)	Generator
0.131	0.124	0.15	**1**
0.306	0.31	0.3	**2**
0.519	0.543	0.55	**3**
1.041	1.016	1.05	**4**
0.524	0.514	0.46	**5**
0.339	0.353	0.35	**6**
605.091	606.04	606.14	Total Cost

Figure number 11 represents costs function convergence based on restrictions and restrictions are modelized in the form of linear equal and unequal equations. whatever repeatition be more , costs function number decrease and converge toward the best answer. When alghorihtm finishes that the repeatition has been finished or reaches to the single imperialist state. Figure 12 shows the productive power based on periunit by each generator in the suggestive method that the most productive power relates to 4^{th} 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.



Fi. 11: changes of costs function

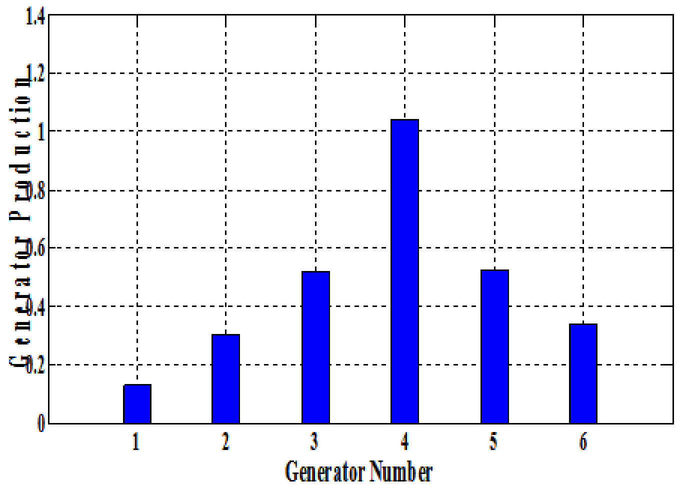


Fig. 12: production measure of each generator

Conclusion:

In this article ICA alghorithm is used for distibuting optimized load in the power system (according to its high speed and its proficiency in the power system). this alghorithm cloges less in the local minimums, so it recalls the purpose function that it leads to high speed, this alghorithm also has less complexity that causes time of problem solving with imperial competitive alghorithm be shorter than other methods in this article. Proper purpose function has been introduced, the result of this work was decreasing power production costs according to problems restrictions. the rsults show that introduced alghoritm acts successfully in finding optimized points. ofcourse these answers are obtained also by assimilation on the bigger netwroks that it did not mentioned in this article. Mentioned optimization stategy can be useful successfully in solving applied and engeneering problems, along with other famous optimization methods such as genetic alghoritm, and optimization of particle group.

REFERENCES

A.El-Keib, H., A. Ding, 1994. ”Environmentally constrained Economic Dispatch using Linear Programming”, Electric Power system Research, 29: 155-159.

Alrashidi, M.R. and M.E. El-Hawary, 2003. “Impact of Loading Conditions on the Emission-Economic Dispatch”. IEEE TRANSACTIONS ON POWER SYSTEMS, 18(4): 1529-153.

Bae, S.H. and R. Yokoyama, 1986. "Optimal generation rescheduling based on multi-objective programming and probability security index," IASTED Power High Tech'86.

Booker, L., 1987. "Improving Search in Genetic Algorithms, in Genetic Algorithms and Simulated Annealing", Pitman, London, pp: 61-73.

Bunch, J.B., R.D. Miller and J.E. Wheeler, 1982. "Distribution system integrated voltage and reactive power
control," *IEEE Transactions on Power Apparatus and Systems*, 101(2): 284-289.

Contaxis, G.C., C. Delkis, G. Kerres, 1986. “Decoupled Optimal Load Flow using Linear or Quadratic Programming”, IEEE Trans. On Power system, 1(2): 1-7.

Esmaeil Atashpaz-Gargari, 2007. Caro Lucas systemfor “Imperialist competitive algorithm:an algorithm for optimization inspired by imperialistic competition” 2007 IEEE Congress on Evolutionary Computation, pp: 4461-4667.

Gnanadass, R., P. Venkatesh, 2008. “Evolutionary programming based economic dispatch of generators with multiple fuel option ramp rate limits and prohibited operating zones” 86: 123-128.

Hur, D., Jong-Keun Park, 2001. “Security Constrained Optimal Power flow for evaluation of transmission capability on Korea electric power system”, Power Engineering Society Summer Meeting, IEEE, 2: 1133-1138.

Kermanshahi, B.S., Y. Wu, K. Yasuda and R.Yokoyama, 1990. Environmental Marginal Cost Evaluation by Non-inferior Surface., IEEE Transactions on Power Systems, 5(4): 1151-1159.

Seifossadat, S.G., M. Saniei1, A. Raeszadeh, 2009. “Reactive Power Pricing in Competitive Electric Markets Using a Sequential Linear Programming with Considered Investment Cost of Capacitor Banks” International Journal of Innovations in Energy Systems and Power, 4(1): 29-43.

Yokoyama, R., S.H. Bae, T. Morita, H. Sasaki, 1988. "Multiobjective OptimalGeneration Dispatch Based on Probability Criteria", IEEE Trans. On Power Systems, 3(1): 317-324.