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Differential Search Algorithm For The Solution of Economic Dispatch Problem

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Abstract: This paper deals with the solution of Economic Dispatch problem of power system by using Differential Search Algorithm. The prime objective of this problem is to schedule the load, between the generators so that total cost of generation of electricity is minimum. Differential Search algorithm(DSA) is based upon Brownian –like irregular movement of the life forms to move starting with one place then onto the next. Scientific model of DSA depicts relocation of living creatures, eu-social, sub-social or pre-social during the time to look the current sustenance ranges since it changes intermittently amid the year. To demonstrate the capability of DSA it is tested on 57-unit large scale power framework.

Keywords: Economic load dispatch, Differential Search algorithm, Brownian motion.

I. INTRODUCTION

The Economic Dispatch (ED) issue is a deliberate errand amongst the most fundamental optimization issues in time of the front line power system [1-4]. ED is characterized as the way toward allotting power values to the thermal units in such a way, so that the load supplied altogether will be at minimum cost while fulfilling different constraints. Throughout the years, numerous endeavours have been made to take care of this issue, fusing various types of constraints or different objectives, through different numerical programming and optimization measures. The traditional strategies incorporate Lambda iteration strategy, base point, gradient strategy [1]. These conventional established dispatch algorithms are based on Lagrangian multiplier technique for which the cost curve must be incremental in nature.

In power system there is always losses in the transmission network. For better and practical feasible solutions losses also must take into the ED problem [5-8].

The resulting ED is a non-convex, non-linear optimization problem, which is a challenging task and cannot be solved by the traditional methods. Researcher did several investigations on ELD problem to provide better solutions. As it would result in saving of money at generation end. In the last decade researchers look to the nature to find optimal solutions of some practical problems of this physical world. In this same effort a novel nature inspired algorithm is used to solve highly constrained problem of power system which is economic dispatch problem. The solution is elegant, considering complexity of the economic load dispatch problem of large scale power system. The convergence rate is fast and also not sensitive to the controlling of parameters.

II. PROBLEM FORMULATION OF ELD

A. *Minimization of Cost:*

The main objective of ELD is to minimize the cost. Which is given by mathematically as per the equation 1.

$$min \quad F_t = \sum_{i=1}^{m} F_{th}(P_i) \qquad (1)$$

$F_{th}(P_i)$ is thermal cost. The cost associated with thermal power generation can be représented as :

$$F_{th}(P_i) = (a_i P_i^2 + b_i P_i + c_i)(\$/hr.) \qquad (2)$$

Where a_i, b_i, and c_i are the fuel cost coefficients of i^{th}thermal unit.

Considering valve point loading (VPL) effect thermal power generation cost depicted as:

$$F_{th}(P_i) = a_i P_i^2 + b_i P_i + c_i + \left|d_i sin\left(e_i\left(P_i^{min} - P_i\right)\right)\right|(\$/hr.) \qquad (3)$$

Where, d_i and e_i are fuel cost coefficients corresponding to VPL effect; *m* is the number of thermal units.

B. *Practical Constraints*

Power balance constraints:

$$\sum_{i=1}^{m} P_i = P_D + P_L \qquad (4)$$

Where P_D is the total demand ; P_L is the transmission network losses, can be represented using B- coefficients:

$$P_L = \sum_{i=1}^{m}\sum_{j=1}^{m} P_i B_{ij} P_j + \sum_{i=1}^{m} B_{oi} P_i + B_{oo} \qquad (5)$$

Generation limits constraints:

$P_{i\,min} \leq P_i \leq P_{i\,max}$

$P_{i\,min}$: Minimum power of i^{th} generator
P_{imax}: Maximum power of i^{th} generator

III. DIFFERENTIAL SEARCH ALGORITHM

Differential search algorithm is developed by Pinar Civicioglu [9] for solution of optimization problem. It simulates the random walk like Brownian motion used by an organism to migrate. In the nature several species shows migration behaviour throughout the year. In nature capacity and efficacy of food varies from time to time. Species move from one place to another since reduction in the food capacity of one habitat and move towards where the efficiency of food is more than previous habitat. Many species like species of birds, honeybees and whales have a periodically cycle of immigration. Movement of these species is carried out by super-organism having large number of individuals. Then this super-organism changes its position in search of better food options.
There are many algorithms that are based upon superorganisms like PSO, Cuckoo search, artificial bee colony and Ant colony. Raptorial living beings can control the fertility of the site which they want to migrate. In DS algorithm first the random population is created and then this population change its position in order to find the local minima. During this process artificial-super-organism tests that the selected position is suitable or not temporarily during the migration. If the selected position is suitable to not moving further for a short duration during the migration, then members of species stay there for a while and continue their migration from this position onwards.

Pseudo-code for DS algorithm is shown in Fig-1. In DS algorithm initialize process is defined as

$$x_i = lb + rand * (ub - lb) \quad (6)$$

here lb is the lower bound of the problem and ub is the upper bound of the problem.

Artificial-organisms are defined by $X_i = [x_{ij}]$ and artificial-superorganism made up of artificial-organisms and is defined as $superoranism_g = [X_i]$.

In DS algorithm mechanism of finding a stopover site may be defined as Brownian-like random walk. Randomly selected individuals of artificial-organisms move towards target of donor $=[X_{random\_shuffling(i)}]$ for discovery of stopover sites. Random_shuffling function of given algorithm changes the order of number of elements in set i={1,2,3…….N} . Size of changes of position of members of artificial-organisms is controlled by scale value that is given in the line 5 of Fig-1. Scale value is given under

$$Scale = randg[2.rand_1].(rand_2 - rand_3) \quad (7)$$

Scale value is produced by gamma random numbers (i.e, randg) controlled by uniform random number generator (i.e, rand) in the range of [0 1] together. Sacle value allows to change the direction of artificial-superorganism radically in the habitat.
In DS algorithm stopover site is given in equation 8

$$Stop\ oversite = superorganism\ scale.*(donor - superorganism) \quad (8)$$

where donor = Superorganism Random shuffling
The members of artificial-organisms of the superorganism to participate in the search process of stopover site are determined by a random process. Structure of this random process is given in Fig-1 (line 8-29). If for some reason any element of stopover site goes above the upper limit or below the lower limit then this element is deferred to another position of the habitat (Fig-1, line 31-33).
DS algorithm has only two control parameters p_1 and p_2 (Fig-1, line 7). Most appropriate values of p_1 and p_2 are p_1=0.3.rand and p_2 =0.3.rand provides the best solution of ELD problem.

IV. IMPLEMENTATION OF DS ALGORITHM TO ELD PROBLEM

In this article differential search algorithm is successfully implemented to different ELD problems. There are many steps for ELD implementation which are given below

Step 1.0- In step 1 the population of superorganisms which represent the power dispatched by different generators is generated by the equation (9) and it is given under

$$P_i = P_i^{min} + rand * (P_i^{max} - P_i^{min}) \quad (9)$$

P_i= Vector contains population of super-organisms which also represents the different value of power dispatched by generators
Pi_{min}= Minimum value of power that can be generated by the ith generator.
P_{imax}= Maximum value of power that can be generated by the ith generator.
rand= any random number between 0 and 1

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Step 2.0- In step 2 different possible generations from different generators ranked on the basis of their fitness i.e. to find the minimum cost.
Step 3.0 – In step 3 donor point is generated with the help of superorganism as shown in equation (10) and (11) in order to discover minimum cost.

$$donor(i,:) = superorganism(rs(i),:) \quad (10)$$

where rs is randomly permutated vector.
Step 4.0- In this step a scale value is generated to control the change of size occurred in the position of member of artificial-organisms. The scale value is generated by using gamma random number generator which is given under.

$$scale=rang\ (2.\ rand_1).\ (rand_2-rand_3) \quad (11)$$

Step 5.0- In step-3 the points obtained above are further improve to find the minimum cost by the stopover-site process, in DSA stop-over-site is defined as the where a particular super-organism stays for a while and then choose its habitat according to the fitness of habitat.

$$stopoversite=superorganism\_scale.(donor-superorganism) \quad (12)$$

Step 6.0- If any one element of the stopover-site goes beyond the search space then it is randomly placed to another position which is described according to equation 13

$$if \quad stopoversite < P_i^{min} \quad or$$
$$stopoversite > P_i^{max}$$
$$then$$
$$stopoversite = P_i^{min} + rand * (P_i^{max} - P_i^{min}) \quad (13)$$

Evaluate stopover-site matrix, create the new superorganism and create the new Superorganism vector.

Step 7.0- in step 6 if minimum cost is found then this process stops here if minimum value of cost is not found in this step then it repeats steps 1 to 6.

V. Results and Discussion:

In this section performance of applied algorithm is judged using two test system of ELD problem with 13 and 40 thermal generators. The test cases as mentioned for ED problem is solved using DS algorithm.
DSA potential is verified on a very large scale power system of 300 buses with 57 generating unit. The cost matrix co-efficient of this test system is given from [10]. The power demand is set 235235.85 MW. The optimum power output achieved by DSA approach is listed in Table-1. Over repeated 20 trial, optimal solution in terms of cost is **566797.446268 $/hr**. Comparison of convergence result with Augmented Lagrange Hopfield Network (ALHN) [10], particle swarm optimization (PSO) [10], differential evolution (DE) [10] and GSA [11] is presented in Table-2. The convergence graph for 57-unit system is depicted in "Fig.2".

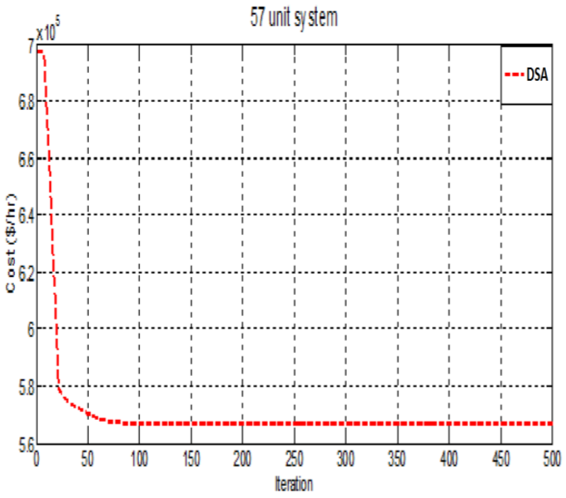

Figure 1 Convergence Characteristics of DSA

Table 1 Comparison of cost obtained by DSA for 57-unit test system

Method	Generation Cost($/hr)
DE [10]	587049.0000
PSO [10]	585276.0000
ALHN [10]	584932.0000
GSA [11]	566797.4932
DSA	**566797.4462**

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Algorithm: Differential search algorithm
N:  The size of population where i ={1,2,3,4,………N}.
D:  The dimension of the problem.
G:  Number of maximum generation.
  superorganism = initialize() , where superoranism =[ Artificial-organism_i]
  y_i = Evaluate (Artificial-organism_i)
for     cycle =1:G do
donor = Superorganism Random_shuffling(i)
Scale = randg[2.rand_1].(rand_2-rand_3)
stopoversite=superorganism+scale.(donor-superorganism)
p_1=0.3.rand_4    and    p_2=0.3.rand_5
if   rand_6 < rand_7  then
if    rand_8 < p_1  then
 r=rand(N,D)
 for            counter1=1:N   do
  r(counter1,:)=r(counter1,:)<rand_9
                 end for
        else
     r=ones(N,D)
           for counter2=1:N     do
        r(counter2,randi(D))=r(counter2,randi(D))<rand_10
        end for
                        end if
  else
      r=ones(N,D)
        for        counter3=1:N    do
     d = randi(D,1,[p_2 .rand.D])
   for    counter4 = 1:size(d)        do
     r(counter3,d(counter4)) =0
   end for
                end for
     end if
   individuals_I,j ← r_I,j  > 0  | I ϵ I,   J ϵ [1,D]
   stopoversite(individuals_I,j) :=superorgansim(individulas_I,j)
     if              stopoversite_i,j < low_i,j   or stopoversite_i,j > up_i,j then
    stopoversite_i,j :=low_j+rand.(up_j-low_j)
     endif
     y_stopoversite,i =evaluate(stopoversite_i)
    y_superorganism,i  :=  f(x) = { y_superoranism,i  if y_stopoversite,i < y_superorganism,i
                                  { y_superorganism,i, i, else
 ArtificialOrgaism_i := f(x) = { Stopoversite_i      if y_stopoversite,i < y_superorganism,i
                               { ArtificialOrganism_i,  else
                           end for
```

Figure 2: Pseudo Code of Differential Search Algorithm

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Table 2 Optimal generation of 57-unit system with power demand 23525.85 MW.

Unit (MW)	DSA	Unit (MW)	DSA
P_1	318.0000	P_{30}	255.0000
P_2	233.0000	P_{31}	900.0000
P_3	435.0000	P_{32}	291.591
P_4	102.0000	P_{33}	467.0000
P_5	99.0000	P_{34}	488.0000
P_6	1640.0000	P_{35}	144.0000
P_7	204.0000	P_{36}	126.0000
P_8	238.0000	P_{37}	396.0000
P_9	591.0000	P_{38}	604.561
P_{10}	71.0000	P_{39}	1028.0000
P_{11}	184.0000	P_{40}	198.0000
P_{12}	87.0000	P_{41}	316.0000
P_{13}	316.0000	P_{42}	495.0000
P_{14}	183.0000	P_{43}	157.0000
P_{15}	174.0000	P_{44}	348.0000
P_{16}	342.0000	P_{45}	425.0000
P_{17}	71.0000	P_{46}	31.0000
P_{18}	300.0000	P_{47}	684.0000
P_{19}	1800.0000	P_{48}	38.0000
P_{20}	1020.0000	P_{49}	248.0000
P_{21}	403.0000	P_{50}	347.239
P_{22}	1677.0000	P_{51}	600.0000
P_{23}	360.0000	P_{52}	174.0000
P_{24}	231.0000	P_{53}	1098.0000
P_{25}	105.453.0000	P_{54}	595.0000
P_{26}	382.0000	P_{55}	470.0000
P_{27}	212.0000	P_{56}	42.0000
P_{28}	257.0070	P_{57}	6.0000
P_{29}	518.0000		
Minimum cost ($\$/hr$)			**566797.4462**

VI. Conclusion

DSA has potential to solve the Economic Load Dispatch with considering the practical operating constraints of the modern power system. The results are better than any heuristic algorithm applied for ELD problem. A large power system network of 300 buses with 57 thermal power units is considered as a test case, DSA has solved this large power system with better results. For future perspective we can say that applied algorithm can be applied further in many power system applications like Economic Emission Dispatch problem, Dynamic Economic Dispatch problem, Optimal Power Flow, Unit commitment.

References

[1]. A. J. Wood and B. F. Wollenberg, *Power Generation, Operation and Control*, 2nd ed., Wiley, New York, 1996.

[2]. M. R. Gent and J. W. Lamont, "Minimum emission dispatch", *IEEE Trans. Power Appar. Syst.* vol. 90, pp. 2650–2660, 1971.

[3]. J. Zahavi and L. Eisenberg, "Economic-environmental power dispatch", *IEEE Trans. Syst. Man Cybern* .vol. 5 no.5,pp. 485–489,1975

[4]. C. Palanichamy and K. Srikrishna, "Economic thermal power dispatch with emission constraint", *J. Inst. Eng.* vol. 72, pp. 11–18, 1991.

[5]. S. O. Orero and M. R. Irving, "Economic dispatch of generators with prohibited operating zones: a genetic algorithm approach", *Proc. Inst. Elect. Eng. Gen., Transm. and Distrib.* vol. 143, no.6, pp. 529-534, 1996.

[6]. A. A. A. E. Ela, M. A. Abido and S. R. Spea, "Differential evolution algorithm for emission constrained economic power dispatch problem",*Electr. Power Syst. Res.* vol. 80, pp.1286–1292, 2010.

[7]. M. Sharma, M. Pandit and L. Srivastava, "Reserve constrained multi-area economic dispatch employing differential evolution with time-varying mutation", *Electr. Power Syst. Res.* vol. 33, pp. 753–766,2011.

[8]. H. M. Dubey, M. Pandit and B. K. Panigrahi , "Hybrid flower Pollination algorithm with time-varying fuzzy selection mechanism for wind integrated multi-objective dynamic economic Dispatch", *Renewable Energy*, vol. 83, pp. 188-202,2015.

[9]. P. Civicioglu, "Transforming geocentric cartesian coordinates to geodetic coordinates by using differential search algorithm", *Comput. & Geosciences*, vol. 46, pp.229–247, 2012.

[10]. V.N.Dieu, P. Schegner, "Real power dispatch on large scale power systems by augmented lagrange hopfield network", Int. J. of Energy Optimization and Engg., vol.1,no.1,pp.19-38, 2012.

[11]. M. Udgir, H. M. Dubey, M. Pandit, "Gravitational Search Algorithm: A novel optimization approach for Economic Load dispatch", DOI: 10.1109/AICERA-ICMiCR.2013.6576006.