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Economic Load Dispatch Problem Based Biogeography Algorithm

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Abstract - In Recent Scenario, scarcity of energy source, ever growing Power demand, increasing in generation cost necessitate optimal economic dispatch. This paper includes Biogeography Algorithm to compute Economic Load Dispatch Problem for Thermal generator of power system. Biogeography Describes how the species arise, migrates from one habitat another and gets wipes out.In BGA model, problem solutions are represents as islands and sharing of features between solution is represented as immigration and emigration which searches for the global optimum mainly through two steps :migration and mutation. BGA has features in common with other biology-based optimization methods, such as GAs and particle swarm optimization (PSO). This makes BGA applicable to many of the same types of problems that GAs and PSO are used for, namely, high-dimension problems with multiple local optimal. To show the advantages of the proposed algorithm, it has been applied to two different test systems for solving ELD problems. First, a 3-generators system then a 6 generators system with simple quadratic cost function considering operating limit constraints is considered.

Keywords: *Economic Dispatch Problem(ELD), Biogeography Algorithm (BGA), Quadratic Cost Function, Operating Limit Constraints*

LIST OF ACRONYMS

ACO	Ant colony optimization.
BBO	Biogeography-based optimization.
DE	Differential evolution.
ES	Evolutionary strategy.
GA	Genetic algorithm.
HSI	Habitat suitability index.
SIV	Suitability index variable.

I. INTRODUCTION

Economic Load Dispatch (ELD) seeks the best generation schedule for the generating plants to supply the required demand plus transmission with the minimum generation cost. As better solutions result in significant economical benefits, so as to improve the solution quality, a lot of researches have been done in this area to improve the solution quality. Previously a number of calculus-based approaches including Lagrangian Multiplier method have been applied to solve ELD problems. These methods require incremental cost curves to be monotonically increasing/piece- wise linear in nature. But the input output characteristics of modern generating units are highly non-linear in nature, so some approximation is required to meet the requirements of classical dispatch algorithms.

Therefore more interests have been focused on the application of artificial intelligence (AI) technology for solution of these problems. Several AI methods, such as Genetic Algorithm; Artificial Neural Networks, Simulated Annealing, Tabu Search, Evolutionary Programming, Particle Swarm Optimization, Ant Colony Optimization, Differential Evolution, Artificial Immune System, Bacteria Foraging Algorithm have been developed and applied successfully to small and large systems to solve ELD problems in order to find much better results. Very recently, a new optimization concept, based on Biogeography, has been proposed by Dan Simon [1]. Historical background of biogeography is very interesting. Biogeography describes how species migrate from one island to another, how new species arise, and how species become extinct. A habitat is any Island (area) that is geographically isolated from other Islands. The more generic term “habitat” in this paper is used rather than term “island”. Geographical areas that are well suited as residences for biological species are said to have a high habitat suitability index (HSI). Features that correlate with HSI include factors such as rainfall, diversity of vegetation, diversity of topographic features, land area, and temperature. The variables that characterize habitability are called suitability index variables (SIVs). SIVs can be considered the independent variables of the habitat, and HSI can be executed using these variables. Habitats with a high HSI tend to have a large number of species, while those with a low HSI have a small number of species. Migration of some species from one habitat to other habitat is known as emigration process. When some species enters into one habitat from any other outside habitat is known as immigration process. Habitats with a high HSI have a low species immigration rate because they are already nearly saturated with species. Therefore, high HSI habitats are more static in their species distribution than low HSI habitats. By the same token high HSI habitats have a high emigration rate; the large numbers of species on high HSI islands have many opportunities to emigrate to neighboring habitats. Habitats with a low HSI have a high species immigration rate because of their sparse populations. This immigration of new species to low HSI habitats may raise the HSI of that habitat, because the suitability of a habitat is proportional to its biological diversity.

BBO mainly works based on the two mechanisms. These are Migration and Mutation. Like GAs and PSO, BBO has a way of sharing information between solutions. GA solutions "die" at the end of each generation, while PSO and BBO solutions survive forever. PSO solutions are more likely to clump together in similar groups, while GA and BBO solutions do not necessarily have any built-in tendency to cluster. Again in BBO poor solutions accept a lot of new features from good solutions. This addition of new features to low HSI solutions may raise the quality of those solutions.

These versatile properties of this new algorithm encouraged the authors to apply this newly developed algorithm to solve non-convex complex ELD problems. The performance of the proposed BGA for a 3,6,10 Generator system with prohibited operating zone method in terms of solution quality and computational efficiency has been compared with GA and for a 3,6,10 Generator system and with prohibited operating zone.

II. BIOGEOGRAPHY

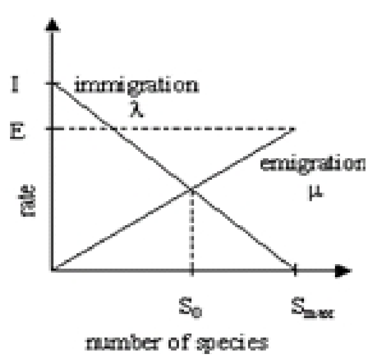

Figure :1

Fig. 1 illustrates a model of species abundance in a single habitat [1]. The immigration rate λ and the emigration rate μ are functions of the number of species in the habitat .Consider the immigration curve. The maximum possible immigration n rate to the habitat is I , which occurs when there are zero species in the habitat. As the number of species increases, the habitat becomes more crowded, fewer species are able to successfully survive immigration to the habitat ,and the immigration rate decreases. The largest possible number of species that the habitat can support is S_{MAX}, at which point the immigration rate becomes zero. Now consider the emigration curve. If there are no species in the habitat then the emigration rate must be zero. As the number of species increases, the habitat becomes more crowded, more species are able to leave the habitat to explore other possible residences, and the emigration rate increases. The maximum emigration rate is E, which occurs when the habitat contains the largest number of species that it can support.

The equilibrium number of species is S0, at which point the immigration and emigration rates are equal. However, there may be occasional excursions from S0 due to temporal effects .Positive excursions could be due to a sudden spur to immigration(caused, perhaps, by an unusually large piece of flotsam arriving from a neighboring habitat), or a sudden burst of speciation (like a miniature Cambrian explosion). Negative excursions from S0 could be due to disease, the introduction of an especially ravenous predator, or some other natural catastrophe. It can take a long time in nature for species counts to reach equilibrium after a major perturbation [1], [1]. We have shown the immigration and emigration curves in Fig. 1 as straight lines but, in general, they might be more complicated curves. Nevertheless, this simple model gives us a general description of the process of immigration and emigration. The details can be adjusted if needed.

III. PROBLEM FORMULATION

The objective of ED problem is to simultaneously minimize the total generation cost (F_T) and to meet the load demand of a power system over some appropriate period while satisfying various constraints The objective function is

$$F_t = \min\left(\sum^{m} F_i(P_i)\right) = \min\left(\sum^{m} a_i + b_i P_i + c_i P_i^2\right)$$

Where P_{Gi}: Power generation of unit i, $F_i(P_{Gi})$: Generation cost function for P_{Gi} and A_i, B_i, C_i: Cost coefficients of i^{th} generator .There are two constraints considered in the problem, i.e. the generation capacity of each generator and the power balance of the entire power system.

Constraint 1: Generation capacity constraint

For normal system operations, real power output of each generator is restricted by lowerand upper bounds as follows

$$P_{Gi}^{MIN} \leq P_{Gi} \leq P_{Gi}^{MAX}$$

Constraint 2: Power balance constraint

The total power generation must cover the total demand P_D and the real power in transmission lines P_L. This relation can be expressed as

$$P_D = \sum_{i=1}^{N_G} P_{gi} - P_L$$

IV. BIOGEOGRAPHY ALGORITHM (BGA)

In this section, we discuss how the Biogeography theory can be applied to optimization problems with a discrete domain. Biogeography Algorithm (BGA) has been developed based on the theory of Biogeography. Biogeography Algorithm is mainly based on Migration and Mutation. The concept and mathematical formulation of Migration and Mutation steps are given below:

I) Migration

This Biogeography Algorithm is similar to other population based optimization techniques where population of solutions is represented as real numbers. Each real number in the array is considered as one SIV. Fitness of each set of solution is evaluated using SIV. In Biogeography Algorithm a term Habitat Suitability Index (HSI) is used which is analogous to fitness function of other population-based techniques, to represent the quality of each solution set. High HSI solutions represent better quality where as low HIS solutions do not give us the desired solution in optimization problem. The emigration and immigration rates of each solution are used to probabilistically share information between habitats. Using Habitat Modification Probability Pmod, each solution is modified based on other solutions. The Immigration rate λ, of each solution is used to decide whether or not to modify each Suitability Index Variable (SIV) in that solution. After selecting the SIV for modification, emigration rates μ, of other solutions are used to select which solutions among the population set will migrate. In order to prevent the best solutions from being corrupted by the immigration process, few elite solutions are kept in Biogeography Algorithm.

II) Mutation

Due to some natural calamities or other events HSI of a natural habitat can change suddenly and it may deviate from its equilibrium value. In Biogeography Algorithm, this event is represented by the mutation of SIV and species count probabilities are used to determine mutation rates. The probability of each species count can be calculated using the differential equation given below:

$$P_s = \begin{cases} -(\lambda_s + \mu_s) P_s + \mu_{s+1} P_{s+1}, & S=0 \\ -(\lambda_s + \mu_s) P_s + \mu_{s-1} P_{s-1} + \mu_{s+1} P_{s+1}, & 1 \leq S \leq S_{max}-1 \\ -(\lambda_s + \mu_s) P_s + \mu_{s-1} P_{s-1}, & S = S_{max} \end{cases}$$

Where

P_s: the probability of habitat contains exactly S species.

λ_s, μ_s: the immigration and emigration rate for habitat contains S species. The Immigration rate (λ_s) and emigration rate (μ_s) .

$$\mu_k = E_k/n$$

$$\lambda_k = I(1-k/n)$$

$$\text{when } E = I, \lambda_k + \mu_k = 1$$

Each population member has an associated probability, which indicates the likelihood that it exists as a solution for a given problem. If the probability of a given solution is very low then that solution is likely to mutate to some other solution. Similarly if the probability of some other solution is high then that solution has very little chance to mutate. Therefore, very high HSI solutions and very low HSI solutions are equally improbable for mutation i.e. they have less chances to produce more improved SIVs in the later stage. But medium HSI solutions have better chances to create much better solutions after mutation operation. Mutation rate of each set of solution can be calculated in terms of species count probability using the equation

$$m(s) = m_{max} \, ((1 - P_s) / P_{max})$$

m_{max} is a maximum mutation rate.

This mutation scheme tends to increase diversity among the populations. Without this modification, the highly probable solutions will tend to be more dominant in the population. This mutation approach makes both low and high HSI solutions likely to mutate, which gives a chance of improving both types of solutions in comparison to their earlier values. Few elite solutions are kept in mutation process to save the features of a solution, so if a solution becomes inferior after mutation process then previous solution (solution of that set before mutation) can revert back to that place again if needed. So, mutation operation is a high-risk process. It is normally applied to both poor and better solutions. Since medium quality solutions are in improving stages it is better not to apply mutation on medium quality solutions. Here, mutation of a selected solution is performed simply by replacing it with randomly generated new solution set.

V. BIOGEOGRAPHY ALGORITHM APPLIED TO ELD PROBLEMS

The algorithm of the proposed method is as enumerated below:

Step1: Initialize the Biogeography Algorithm parameters as follows: Habitat Modification Probability Pmod, Mutation Probability, Maximum mutation rate m_{max}, maximum immigration rate I, maximum emigration rate E, number of iterations, elitism parameter p, number of SIVs m, of Biogeography Algorithm, number of Generating units, number of Habitats N.

Step2: The initial position of SIV of each habitat should be selected randomly while satisfying different equality and inequality constraints of ELD problems. Several numbers of habitats depending upon the population size are being generated. Each habitat represents a potential solution to the given problem.

Step3: Calculate the HSI i.e. the value of objective function for each habitat of the population set for given emigration rate μ, immigration rate λ, and species S. Here, in ELD problem HSI^i represents the fuel cost function of i-th generation set (i.e. i-th habitat) in \$/hr. SIV^{iq} represents the value of power output of q-th generator of i-th habitat set H^i. In this paper, each habitat is a vector with m generating units. Each individual habitat within the total of H habitat represents a solution for solving the ELD problem.

The i^{th} individual H^i can be defined as follows:

$H^i = SIV^{iq} =[SIV^{i1}, SIV^{i2}, \ldots\ldots\ldots\ldots , SIV^{im]}$

Where i =1,2,...S; q =1,2,...m

Where, SIV^{iq} is the power output of q-th unit of i-th individual.

Step4: Based on the HSI value elite habitats are identified.

Step5: Each non-elite habitat is modified by performing probabilistically migration operation and HIS of each modified set is recomputed. Feasibility of a problem solution is verified.

Step6: Go to step (3) for the next iteration.

Step7: Stop iteration after a predefined number of iterations.

VI. DETERMINATION OF PARAMETERS FOR BGA ALGORITHM

To get optimal solution using the BGA algorithm, the best values of the parameters like mutation probability, step of integration and habitat size have to be determined.

- The habitat size is fixed at 10.
- Step of integration is increased from 0.1 to 2 in suitable steps. Mutation probability is changed to two different values of 0.05, 0.005.
- For each combination, 50 iterations per trial have been made.

VII. DESCRIPTION OF THE TEST SYSTEMS

Case Study -1: Three Units System

In this example, a simple system with three thermal units is used to demonstrate how the proposed approach works. The Output Table Provides the statistic results that involved the Total generation cost comparing with GA algorithm

Table 1:

GENERATING UNITS CAPACITY AND COEFFICIENTS

BUS DATA

3 – bus system

P_D=850MW

S.NO	a_i	b_i	c_i	P_{gimin}	P_{gimax}
1	0.001562	7.92	561	150	600
2	0.001940	7.85	310	100	400
3	0.004820	7.97	78	50	200

Table 2:

BEST POWER OUTPUT FOR 3 UNIT SYSTEM WITHOUT TRANSMISSION LOSS

(P_D = 850 MW)

Unit Power Output	BBO	GA
P_1 (MW)	386.36	510.27
P_2 (MW)	347.72	213.73
P_3 (MW)	115.90	125.99
Total Generation Cost (\$/h)	8188.09	8188.14

Case Study -2: 6 Units System

In this example, a simple system with six thermal units is used to demonstrate how the proposed approach works. The Output Table Provides the statistic results that involved the Total generation cost comparing with GA algorithm.

Table 1:

GENERATING UNITS CAPACITY AND COEFFICIENTS

Table 2:

BEST POWER OUTPUT FOR 6 UNIT SYSTEM WITHOUT TRANSMISSION LOSS
(P_D = 1800 MW)

Case Study -3: 10 Units System

In this example, a simple system with Ten thermal units is used to demonstrate how the proposed approach works. The Output Table Provides the statistic results that involved the Total generation cost comparing with GA algorithm.

Table 1:

GENERATING UNITS CAPACITY AND COEFFICIENTS

Table 2:

BEST POWER OUTPUT FOR 10 UNIT SYSTEM WITHOUT TRANSMISSION LOSS
(P_D = 2700MW)

VIII. CONCLUSION

The Biogeography Algorithm method has been successfully implemented to solve ELD problems with the generator constraints. From the result, it is clear that the BGA algorithm has the ability to find the better quality solution and has better convergence characteristics, computational efficiency with genetic algorithm.

REFERENCES

[1] Simon,Dec.2008.“Biogeography- Based Optimization”, IEEE transactions on Evolutionary computation, vol. 12, No. 6, pp. 702-713

[2] Aniruddha Bhattacharya and Pranab Kumar Chattopadhyay, May 2010. “Biogeography - Based Optimization for Different Economic Load Dispatch Problems”, IEEE transactions on power systems, vol.25, no. 2. .

[3] N. Sinha, R.Chakrabarti, and P.K.Chattopadhyay, “Evolutionary programming techniques for economic loaddispatch, ”IEEE transactions On Evolutionary Computation,vol.7,No.1,pp. 83–94,Feb. 03

[4] M.Vanitha, k.Thanushkodi “An Efficient technique for solving the Economic Dispatch Problem using Biogeography Algorithm” ISSN 1450-21X Vol.50 No. 2(2011),pp.165-172

[5] K.P.Wong and C.C.Fung, Nov.1993.“Simulated Annealing based Economic Dispatch Algorithm”, Proc. Inst. Elect. Eng., Gen., Trans. and Distrib., vol. 140, no. 6, pp. 509-515.

[6] Po-Hung Chen and Hong-Chan Chang, Nov. 1995. “Large-scale Economic Dispatch by Genetic Algorithm”, IEEE Transactions on Power System. Vol. 10. No. 4.

[7] Chao-Lung Chiang, Improved Genetic algorithm for Power Economic Dispatch of Units With Valve-Point Effects and Multiple Fuels , IEEE transactions on power systems, Vol.20, No0.4, November 2005, page no. 1690-1699.

[8] A. G. Bakirtzis, P. N. Biskas, C. E. Zoumas, and V. Petridis, “Optimal power flow by enhance genetic algorithm,” IEEE Trans. Power Systems,vol. 17, pp. 229-236, May 2002

[9] D.C.walters, G.B. Sheble, Genetic algorithm solution of economic dispatch with valve point loading, IEEE transactions on power systems,8 (August1993). 1325-1332.

[10] J. Wood and B. F. Wollenberg, 1984. “Power Generation, Operation and Control”, 2nd ed.,Wiley

[11] MacArthur and E. Wilson, 1967. “The Theory of Biogeography”, Princeton, nj: Princeton Univ.Press Wallace, 2005. “The Geographical Distribution of Animals (Two Volumes)”, Boston, ma:Adamant Media Corporation

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